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# GOLD PRICES AND THE VITWATERSRAND

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R. A. LEHFELDT



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# **STUDIES IN ECONOMICS AND POLITICAL SCIENCE**

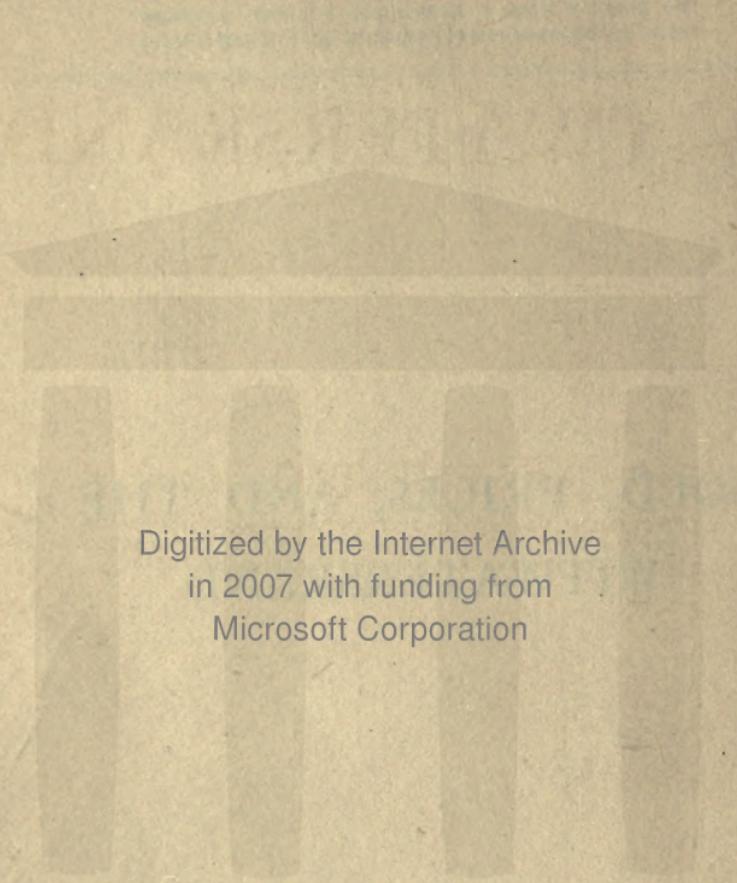
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Director of the London School of Economics and Political Science**

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## **GOLD, PRICES, AND THE WITWATERSRAND**



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# GOLD, PRICES, AND THE WITWATERSRAND

BY

R. A. LEHFELDT, D.Sc.

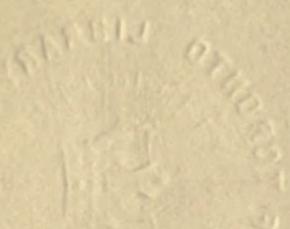
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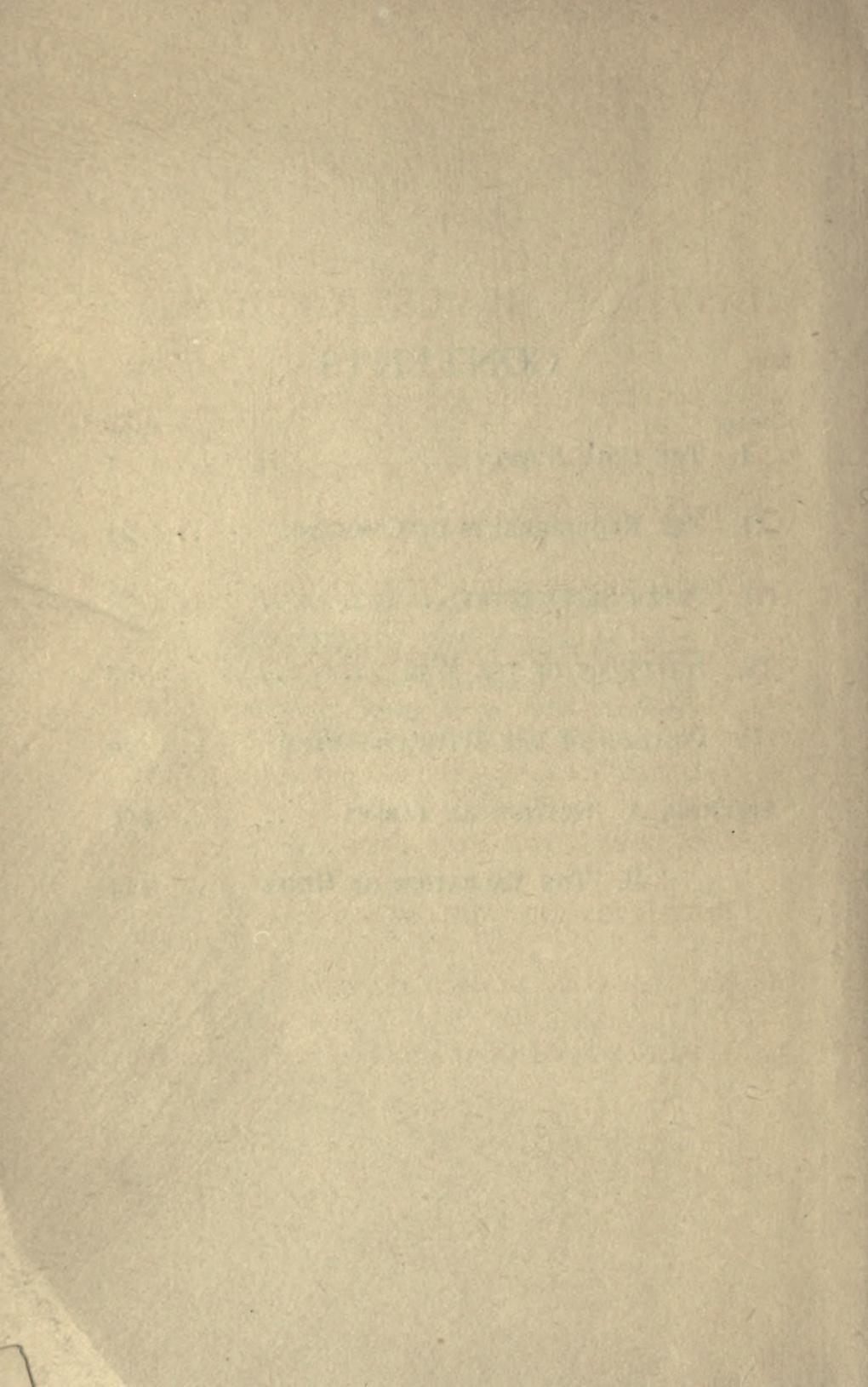
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# GOLD, PRICES, AND THE WITWATERSRAND

## CHAPTER I.

### THE GOLD SUPPLY.

Outline of the history of the production of gold—Disposal of the product—Estimate of the stock accumulated, and its rate of increase—Outline of the history of prices—The quantity theory of money in a primitive stationary community—Modifications required by growing scale of trade, and by the use of paper money—The course of prices must be compared with the course of the stock, not of the production of gold.

To understand the relations between the supply of gold and the general level of prices, it is necessary to bear in mind the outlines of the history of each.

Beginning with the supply of precious metal, we are faced with this difficulty, that whilst at the present day gold is the sole

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standard of value through nearly all the civilised world, in past times gold and silver were used jointly. The change has come about gradually, and is not yet complete, so that it is difficult to say with regard to any period whether the stock of gold only, or of gold and silver, or of gold and a part of the silver, should be regarded as the basis on which the monetary system of the world lay.

It is well known that gold and silver were very scarce in the Middle Ages, and that an increased supply came into use after the discovery of America. Thereafter until the nineteenth century no change of the first magnitude occurred, and we may conveniently begin our study when the disturbance due to the Napoleonic wars had subsided, say about 1825. At that time the annual output of gold was about two million pounds worth. In the course of the next twenty years the output increased slowly, chiefly on account of discoveries in Russia, but did not exceed some four millions at the date of the Californian discovery. The available stock at that date was about £150,000,000.

The starting of the Californian mines, followed almost immediately by those in Australia, raised the output in the course of five years to thirty millions—ten times what it had been only a little while before.

The usual history of a minefield is that after the rush to use the ore immediately exposed a falling off takes place ; then more careful methods and improvements in technique restore the output for a while ; lastly comes the inevitable decline and exhaustion. This has been the history of the goldfields. By the early eighties the world's production had fallen to about twenty millions a year. At the present day California yields about four millions, chiefly from deep level mines, and the colony of Victoria less than two millions a year.

The supply of gold was restored by the finding of the Witwatersrand fields in 1887, of the alluvial deposits in Alaska, and the mines of Western Australia, as well as of new deposits in the United States. As a consequence the output reached ninety millions in 1908, since when it has remained approximately constant. The Witwatersrand, how-

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ever, is affording an increased share of the whole.

### OUTPUT OF GOLD\* (IN THOUSAND POUNDS).

	Transvaal.	Rest of world.	Total.	% Transv.
1908	29,973	61,022	90,995	33.0
1909	30,988	62,312	93,302	33.2
1910	31,973	61,571	93,544	34.2
1911	35,041	59,889	94,930	36.9
1912	38,712	57,071	95,783	40.4
1913	37,373	56,043	93,416	40.0
1914	35,657	57,197	92,854	38.3
1915	38,628	57,668	96,296	40.1
1916	39,475	56,250	95,725	41.3
1917	38,306	51,694	90,000	42.6

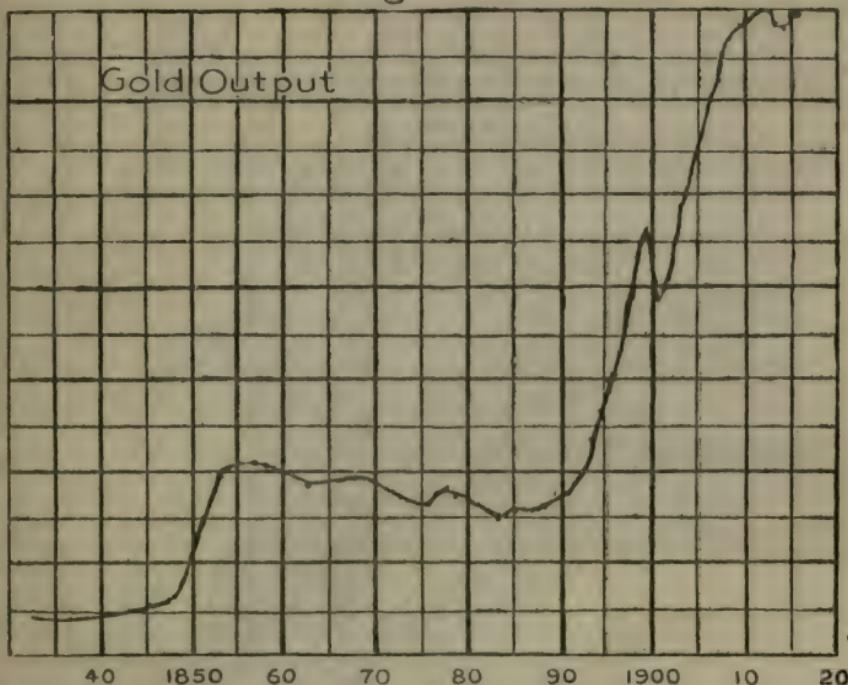
It will be noticed that the production of the rest of the world shows a tendency to fall off, but that the deficiency has been met so far from the Witwatersrand. Figs. 1 and 2 give the annual output in graphic form.

What is of immediate interest for monetary theory is not, however, the output, but the available stock of gold. This cannot be arrived at by simply accumulating the figures

\* Transvaal Chamber of Mines, Twenty-eighth Report, pp. 367, 370.

of annual production, for a large amount of gold is used up in ways that make it unavailable as money. Some, which is used in photographic chemicals, in gilding, and other arts,

Fig. 1



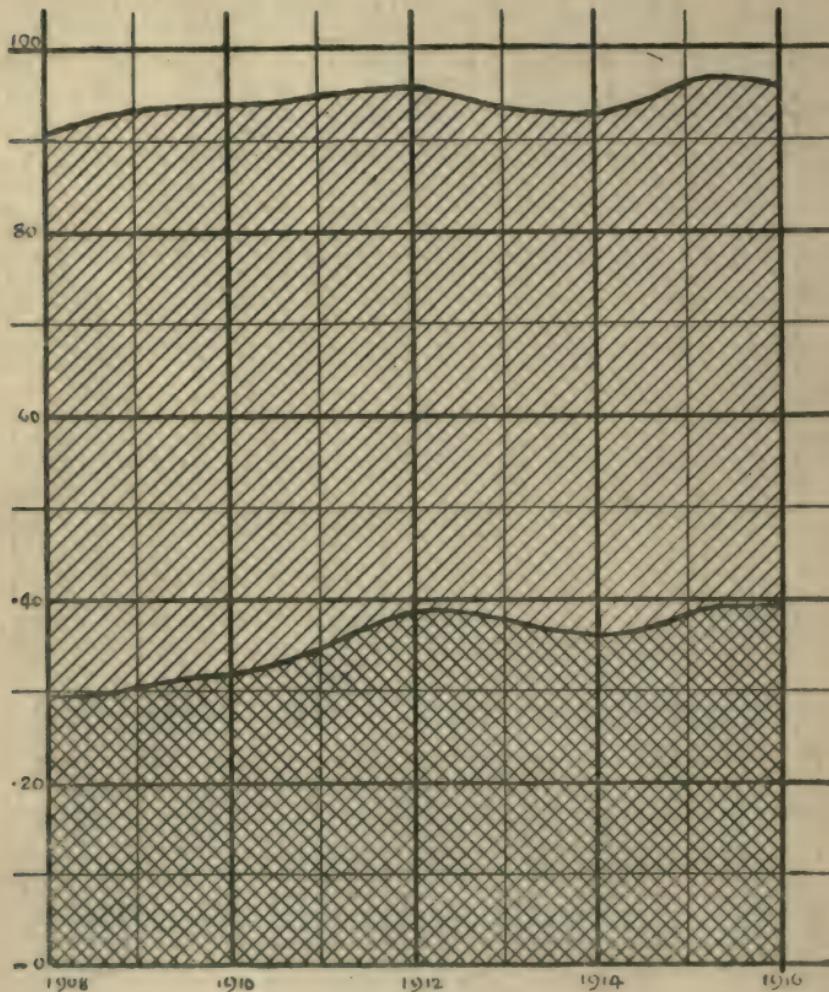
is reduced to such a fine state of division that it can never be recovered; other portions are converted into jewellery, which might conceivably be coined—in the stress of the present war some of it has been—but in ordinary circumstances must be considered

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unavailable. Moreover, jewellery and coins, too, suffer wear ; and gold occasionally gets lost in the sea.

**GOLD OUTPUT.**  **REST OF WORLD**  
**TRANSVAAL.**

*Fig. 2.*



There is another influence to be taken into account. The people of India have for centuries had an inordinate love for gold and silver, and spent a large part of their scanty earnings in accumulating coins and ornaments, which they hoard. India is in fact a regular sink for the precious metals, into which they disappear. It should, indeed, be borne in mind that considerable stores of gold and silver might be given out again by the people of India should they change in their taste for ornament, or should they come to appreciate the advantages of modern banking as compared with hoarding money.

For the present it is probably best to exclude India altogether from the commercial world whose monetary supply we are considering.

We shall also exclude China, Siam, and French Indo-China, but for a different reason. These countries use silver as their standard money. In India the usual money is of silver, it is true ; but the rupee is only a token coin. Its value is greater than the value of the silver it contains, being one fifteenth part of the value of a sovereign, for the reason that the

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Government of India is always willing to give a sovereign for fifteen rupees. But in China silver, whether coined or not, stands on its own base as money ; a payment due in China is a payment of so much silver irrespective of the weight of gold which may at the moment be exchangeable for it.

We may then best consider the world without India and China as one community using money on a gold basis, and proceed to estimate the stock of gold it possesses. The best estimates are those of the United States Mint. Particularly careful statistics for the United States are kept, and the Director of the Mint gives estimates for other countries, based, so far as possible, on official information. The statistics are admittedly incomplete, several of the smaller countries—South Africa among them—affording no proper returns. The total however will not be very much out. At the beginning of 1914 it is given as \* :—

Gold in banks and public treasuries . . .	£m1,139
Gold in circulation . . . .	552
Total . . . .	£m1,691

\* United States Mint Report, 1915, p. 63.

There are two ways of studying the change in stock. One is to make periodical estimates of the gold in banks and in circulation, similar to the above; the other is, starting from a given date, to add up the statistics of production after allowing for export to the East, consumption in the industrial arts, and wear and tear. Fortunately the two methods are found to give results in reasonable agreement.

As a sample let us take the figures for the quinquennium 1901-5 inclusive. The total value of gold produced from the mines was £331,000,000. The Indian customs returns give a pretty trustworthy account of the movement to and from that country, and show that on balance £21,000,000 worth of gold went there. The U.S. Mint publishes estimates of the metal used in the arts; the estimates for consumption in America are fairly accurate, those for many other countries less so. Taking them as they stand, it appears that £80,000,000 worth of metal was used in manufacture (of which more than a quarter was used in the United States). There remained therefore a balance of about

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£230,000,000 added to the available monetary stock.

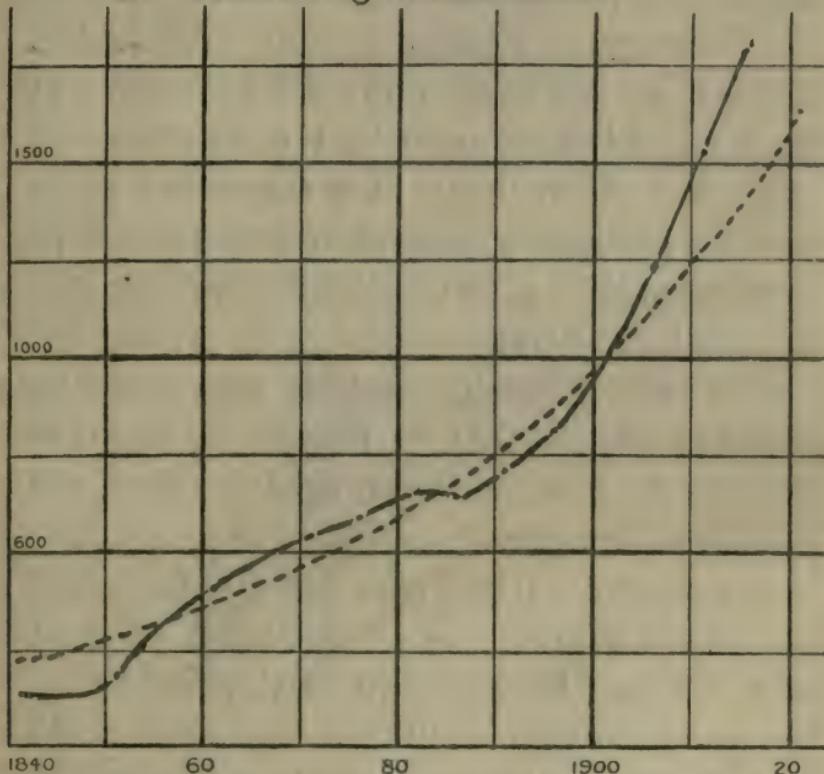
The drain to India fluctuates according to the prosperity of that country. As far back as the middle of the last century India sometimes imported five or six million pounds worth a year, whilst in years of bad harvest there is sometimes a net export. But from 1907 until the outbreak of the great war the flow to India reached a magnitude previously unknown, sometimes exceeding twenty million pounds worth a year, and so absorbing a quarter of the whole output. It is impossible to say what will happen after the war; but if India continues to prosper and retains its taste for jewellery, no doubt a large part of the output of the mines will be sent there. One must remember the vastness of the population; large as the recent exports seem, the largest annual figure does not amount to two shillings worth of gold per inhabitant.

With regard to the industrial consumption in the rest of the world, the rate of increase is not greater than is to be expected from the growth of population, wealth, and luxury. Soetbeer estimated that in Californian times

(1850-60) some four million pounds worth a year was used in the arts; the latest figures indicate about twenty-four million pounds

Fig 3

Actual and required stock of gold  
(excluding India & China)



worth. The result of these calculations, checked by comparison with the known currency at intervals, is shown in Fig. 3. It will be seen that the monetary stock is now

more than tenfold what it was before the Californian discoveries, and nearly threefold what it was before the discovery of the Rand. The world, of course, requires more gold than it did, as it has a larger amount of business to transact; the question to discuss is whether the increase in stock has been more or less rapid than the world's growth calls for. It may be noted at once that the increase in stock has taken place in a somewhat jerky manner, while the increase in trade has been steady, so that a certain want of adjustment is to be looked for.

The other historical outline that must be borne in mind is that of the general trend of prices. It is a truism nowadays that the purchasing power of money is not constant. Through the early years of the twentieth century a steady rise in the price of most articles forced itself on public attention; then the war came, to make the change so acute that no one could overlook it. It must not be supposed, however, that a change in the purchasing power of money is a new thing; change in one sense or the other has always been going on, but it is only of late years that

the efforts of economists have given exact expression to it. At the same time more frequent discussion in parliaments and newspapers, and especially the increased share in public affairs taken by the working classes, has made the notion familiar to every one.

The principal use of money is to be a standard of value, and it is consequently a natural error to fall into to suppose that the value of money is invariable. It is hardly necessary to remark that the constant price of gold has nothing to do with the question. The fact that 1,000 ounces of gold are always coined into 4,248 sovereigns tells nothing as to whether the sovereign is worth much or little. The value of gold does not vary rapidly in ordinary circumstances because the stock of money is very large, so that the supply is not exposed to fluctuation in the same way as an animal or vegetable product, which is dependent on the seasons. But though the variations in the value of money are slower than those of most important commodities, they are not less great in extent.

In order to study changes in the value of money, economists have introduced the device

of index numbers. When the price of a commodity goes up or down that may be due to some change affecting the commodity or some change affecting money. It is unlikely that all commodities should, in ordinary times, be influenced in the same direction by circumstances peculiar to each. A bad harvest may raise the price of wheat one year, a failure of the rubber trees may raise the price of rubber another year; but it is very unlikely that there should be bad harvests of wheat, maize, rubber, cotton, sugar, and rice simultaneously, and still more unlikely that the prices of these articles and also of animal and mineral products should all rise or all fall together.

Economists therefore take an average of the prices of many suitable materials in order to eliminate causes affecting them singly. But the price of anything is the proportion in which it exchanges for gold, so that if the prices of many things rise it is highly probable that the cause is to be found in something that makes gold less valuable, and conversely when prices in general fall, the cause is probably an increase in the value of gold.

"Probably" because there are conditions which affect the price of all commodities together. Of these the most important is war, which makes productive labour scarce, transport difficult, and in every way raises the real cost of goods. When, therefore, the index number of price rises in the course of a great war, it cannot be concluded without further evidence how far the rise is due to monetary influences and how far to difficulties of production. But in peace-time it is safe to say that considerable changes in price level are due principally to monetary changes.

Such an index number as that published for many years by Mr. Sauerbeck, and now continued by the *Statist* newspaper, is found by expressing the prices of important raw materials as percentages of the prices during some period chosen as a basis and then finding the mean of those percentages. If, for example, the decade 1868-77 is chosen as basis, and the index number for a certain year is 82, that means that £82 will then go as far in buying raw materials and foodstuffs as £100 would in 1868-77. About forty-five

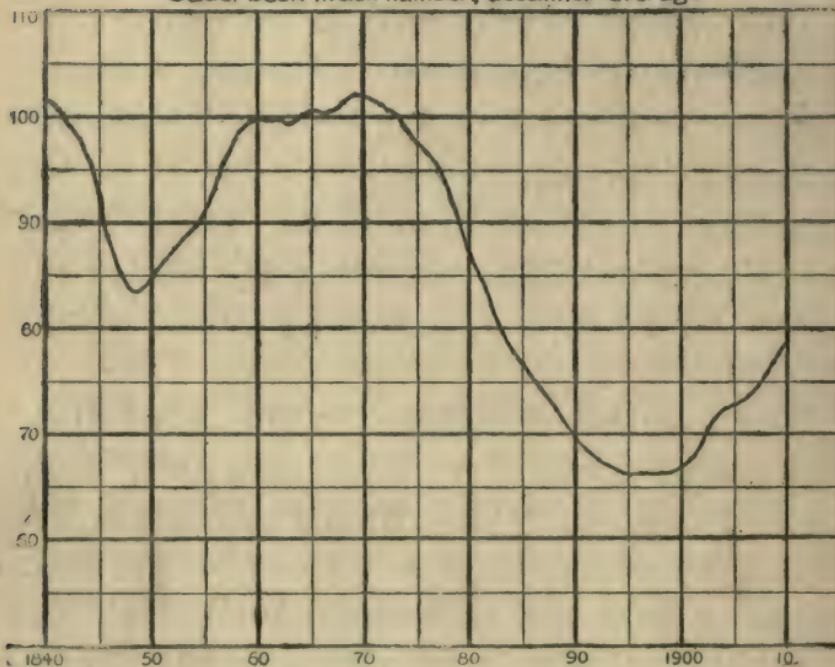
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materials were used by Sauerbeck in making the calculation.

In order to eliminate unimportant details in the history of prices and bring out clearly

Fig. 4

Sauerbeck index number, decennial average



the main tendencies, it is well to take a decennial average of index numbers; *i.e.*, instead of the index for 1905 we take the mean of the years 1900–9, instead of 1906 the mean of 1901–10, and so on. Fig. 4 is constructed in this way. The figure shows

that prices were on the down-grade before the Californian discoveries, rose to a maximum and remained fairly steady in the sixties, fell continuously and largely till a few years before the end of the nineteenth century, and have been rising since. There have thus been four broad movements in the course of a century—two up and two down. We have heard so much of rising prices lately that it has been forgotten how recent the movement is, but the older men amongst us can remember the days when the constant complaint was of falling prices. The diagram shows that we have not to go very far back in history to find that the difficulties we are now meeting with have been met and overcome before.

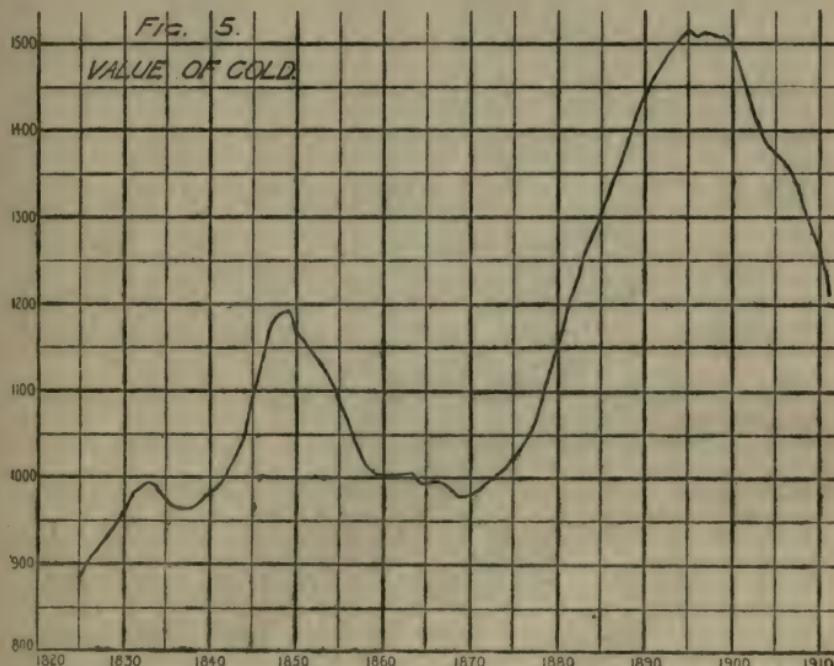
When an ordinary commodity becomes more valuable, the fact shows itself by a rise in its price; when the standard of value—gold—becomes more valuable, the effect is a fall in the price of other things. This inversion, though not really complicated, has given rise to much confusion at times, and in order to think clearly on the subject a certain device may be recommended—that of choosing some other standard material, such as

wheat. There is no difficulty in understanding such statements as "The price of a suit of clothes is twelve bushels of wheat," "The doctor charges two bushels a visit." There would be no need to carry sacks of wheat about with one in order to fulfil such transactions, for payments might be made by cheque. Now at the beginning of this century an ounce of gold was worth twenty-six bushels, before the outbreak of the great war it had fallen to seventeen bushels, and at the present day it is only worth about ten. This way of putting it, perhaps, brings out more clearly the depreciation of gold that has been going on.

Economists do not use wheat as standard because it is liable to fluctuations of its own, but, as explained above, they take the average of a number of commodities. If we take the reciprocals of Sauerbeck's index numbers we shall get a series of numbers indicating the value of gold, that of goods in general being regarded as constant. The series is represented in Fig. 5, and may be regarded as a correct statement of the fluctuations in the value of gold, except in war-time, when diffi-

culties of production raise the value of ordinary goods.

We have now to compare the history of gold production with the history of prices. The relation between the two given by the classical



economists is known as the quantity theory of money ; this is most easily expressed with regard to a primitive type of community, and it will not be a waste of time to state it so in the first place, although the economic conditions assumed will strike the reader as being

very far away from those of the actual world.

Let us then suppose a country with stationary population, and industry that goes on from year to year without change, in which the only money used (except for small change) consists of gold coins. Then if the stock of gold were to be increased by importation or by the discovery of a mine prices would rise, for there would be no more goods to pay for, and the increased stock of gold could only be used by paying more of it for each thing bought. It may perhaps be objected that the new gold would not be used, only hoarded ; but why should the owners of it forego their advantage ? Let the objector imagine himself in the position of the hoarder of gold ; he has a considerable quantity of gold coins that he does not know how to use, and is in want of, say, a pair of boots. Will he not rather bid up the price of boots than go without ? The statement that—*ceteris paribus*—prices rise and fall in proportion to the stock of money is the “ quantity theory ” in its primitive form.

The chief differences between our imagined

community and the actual world are, firstly, that the world's population, trade, and wealth are increasing rapidly, and, secondly, that we make a great part of our payments by means of paper money and cheques. We shall proceed to consider these points, but must advert to a fallacy that is often made in discussing the quantity theory. If Fig. 1, on the production of gold, be compared with Fig. 4, on the level of prices, it will be seen that the two are not alike. That has been brought forward, erroneously, as an argument against the quantity theory. As a matter of fact there are certain points of similarity, both curves show a rise about 1850 and again at the end of the century, but no one who was not looking for analogies on preconceived grounds would say that they were similar. But they must not be expected to look alike ; if the quantity theory is true the two curves ought not to be alike ; if they were alike that would be evidence that the theory was not true.

According to the quantity theory, the level of prices is dependent on the stock of money. Fig. 1 represents only the RATE OF CHANGE of the stock, and therefore cannot look similar

to the curve of prices. This will be clear if we revert to the imaginary community using gold. Suppose the stock is a hundred millions, and the annual production nothing, and that then a mine is discovered yielding a million a year. The curve of production jumps suddenly from nothing to one million and remains constant at that. The curve of prices will rise from its previous steady level gradually year by year as the stock of gold increases, till in a hundred years it will be double its original height. The two curves are entirely dissimilar. Hence the fact that the historical curves of gold production and of prices do not look alike is no argument against the quantity theory.

It is clear, however, that in the actual world the increase in trade implies an increase in the demand for gold, and the real question is not whether the supply is increasing, but whether it is increasing faster or less fast than the demand. To discuss that we must first get information as to the rate of increase of the world's trade ; that will be the subject of the next chapter.

## CHAPTER II.

### THE REQUIREMENTS OF COMMERCE.

The rate of increase in demand for gold—The increase in population of the commercial world—Increase in real wealth. (Digression on increase in governmental expenditure.)—Production of staple foods and raw material—Growth of transport and manufacture—General estimate of rate of increase. Estimate of stock of gold required to meet the needs of trade—Comparison with the actual stock—Ratio “actual  $\div$  required stock” compared with course of prices.

WE have now to consider how fast the demand for gold is increasing. The demand arises from the growth of commerce, and may be met partly by economy in the use of gold, a point that will be dealt with later ; it is first necessary to study the rate of growth of the world's production and trade in itself.

There is at the present time a fairly rapid growth in population of the world, so that even if the quality of the population remained the same, and the methods of industry were

not changed, more money would be needed to carry on trade. But, as a matter of fact, the improvement in education and health of the community and the progress of invention are continually raising the productivity of the individual, so that wealth grows faster than population.

Even though we exclude the Orient, for the reasons given in the last chapter, the world's inhabitants are at very diverse levels of commercial civilisation. The population of Europe itself is growing at about 1 per cent. per annum. It has been estimated as follows :—

1830	.	213	millions.
1870	.	300	„ Increase 0.90 per cent. per annum.
1910	.	448	„ „ 1.12 per cent. per annum.

But the new countries grow faster, and not only so, but there are countries which at the earlier dates were hardly within the circle of European commerce, but which now take their part. Accordingly the notion of a rate of increase in population is somewhat indefinite ; but in making a practical estimate North America, Australia, New Zealand,

South Africa, Siberia, Algeria, and Egypt have been included with Europe at the earlier dates, and Japan, Central and South America, added for the latest date. Reckoned in this way, the numbers are :—

1830 . . .	232 millions.	
1870 . . .	355 "	Increase 1.16 per cent.
1910 . . .	710 "	per annum. , , 1.84 per cent. per annum.

It appears then that of late years the populations we are concerned with—those who take a part in modern commercial life—have been increasing at a rate between  $1\frac{1}{2}$  and 2 per cent. The rate of increase in wealth must certainly be greater than this.

What we require to know is the real production of goods ; to study money incomes and find the rate at which they are increasing would not give the information sought after ; it would indeed be reasoning in a circle. Nevertheless, in passing, it is perhaps worth while to note one special class of money incomes, those of Governments, on account of the particularly good information available.

The Governments of Europe had in 1870

a revenue of £445,000,000, in 1910 about £1,260,000,000 (excluding railway revenue). Now the State has of late taken on new functions which make its share of the total resources of a country to increase ; but, on the other hand, old war debts, while not as a rule paid off, come to be relatively less important as the world grows richer. On the whole it would be difficult to say whether a greater or smaller fraction of the world's income passed through the hands of the Governments in 1910 than in 1870. *If* we assume that the fraction was the same we get a rate of increase of 2·7 per cent. per annum from the above numbers. This result being already expressed in terms of money, must be received with caution ; but it is probably not far from the real rate of increase of wealth, and so throws a certain light on our problem.

The level of prices was somewhat higher in 1870 than in 1910, so that the income of the latter date would appear still larger if it were expressed in terms of the purchasing power of money at the former. Hence the rate of increase of true income was rather greater than the figures show.

Turning now to direct statistics of production, we have information, more or less accurate, as to the world's output of raw materials and foodstuffs. As an example the following figures for cotton have been extracted from well-known statistical dictionaries :—

#### WORLD CROP OF COTTON.

					Millions of pounds.
1831	..	..	..	..	820
1840	..	..	..	..	1,310
1850	..	..	..	..	1,435
1860	..	..	..	..	2,551
1870	..	..	..	..	2,775
1880	..	..	..	..	3,601
1891	..	..	..	..	5,600
1892	..	..	..	..	5,900
1902	..	..	..	..	8,660
1906	..	..	..	..	10,490

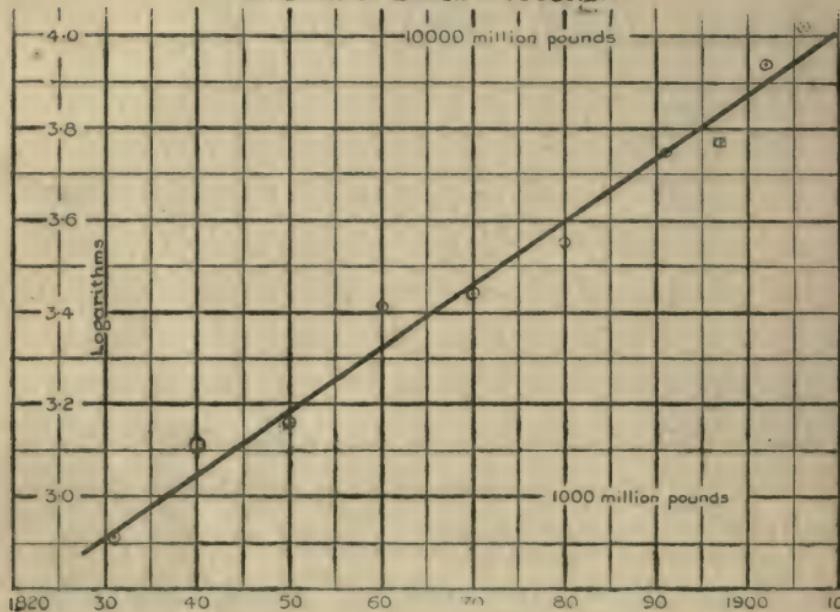
These figures require to be analysed by a suitable mathematical method to find the average rate of increase. The method is to take the logarithms of the quantities and plot a graph of them against the dates as abscissæ. This is done in Fig. 6. It will be seen that a straight line can be drawn through the points on the diagram without leaving them very far on either side. The straightness of the line of points indicates that the rate of

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growth has been steady ; the steepness of the line indicates how rapid the growth has been.

For cotton the result is a rate of increase of 5·2 per cent. per annum, maintained

Fig 6  
Growth of Cotton Production



with but little fluctuation for the last three quarters of a century. It is by combining a number of results like this that an estimate can be formed of the rate of material progress.

It is not easy however to decide what weight

should be given to the different items of production. A large part, probably the largest part, of human effort is still devoted to producing food ; but an estimate based on food alone would be an underestimate, because with the progress in efficiency an increasing share of effort can be given to objects less necessary than food. Raw materials such as iron, copper, rubber, are increasing in importance, and also the industries of manufacture and transport. Manufacture takes, of course, a very important place ; the fraction of the world's population so occupied is increasing, and the individual worker is growing more efficient, but any general estimate of the rate of progress would be hard to arrive at.

For transport a better estimate can be made. Thus the tonnage of ships has been growing of late years by nearly 4 per cent. per annum, and the mileage of railways at about the same rate. But as ships grow speedier, and railways acquire more traffic per mile, the progress of transport must be faster than that.

Reverting to the production of foodstuffs and raw materials for which the most precise

figures are obtainable, the following table has been derived (see Appendix, Table VII.):—

				Annual rate of increase.
Meat ..	..	..	..	1·0 per cent.
Corn ..	..	..	..	1·5 „
Tea and coffee		..	..	2·5 „
Sugar ..	..	..	..	5·0 „
Wool ..	..	..	..	1·9 „
Cotton		..	..	3·2 „
Pig iron		..	..	4·8 „
Coal ..	..	..	..	4·8 „

The result for meat being actually less than the rate of increase of population, seems doubtful ; but there is no doubt that meat is growing scarce and expensive. An investigation by the present writer,\* undertaken for a different purpose, gave 2·2 per cent. as the rate of increase for wheat ; this accords well with the figure given above for corn, as no doubt wheat is coming to be used by many people in place of cheaper kinds of corn. In the same way the high figures for tea, coffee, and sugar are an indication of growing luxury. The richer nations are already fairly well supplied with bread and meat, and are there-

\* *Econ. Journ.*, vol. xxiv., p. 212.

fore able to spend an increasing part of their income on less necessary foodstuffs.

Wool, like meat, is growing relatively slowly in amount. Wool and cotton combined give (allowing for the greater importance of cotton) an index of 2·8 per cent., which shows that the supply of clothes is gaining considerably on the number of wearers. The very high rates for iron and coal are, of course, a sign of the immense progress that is being made everywhere in structural work and the application of mechanical power.

As a sidelight on the problem it is well to refer to a careful estimate by Prof. Irving Fisher of the whole trade of the United States over the period 1896 to 1912. The table which he gives \* yields a rate of increase of 4·9 per cent. per annum. This is certainly an upper limit to the rate of the world's progress, for it is a matter of common knowledge that, even excluding the Orient, the rest of the world has not progressed as fast as the United States.

It is evident that there is a large margin of error to any final estimate for the world. If

\* "Purchasing Power of Money," p. 479.

we were to choose 2 per cent. the population statistics alone would tell us that the rate was too low ; if we chose 4 per cent. a consideration of the figures for foodstuffs and of the vast importance food production still exercises in the world's economy would show that the rate was too high. We cannot go much beyond saying that the true rate lies between 2 and 4 per cent., and is therefore not very different from 3 per cent.

We have now got an answer, even if rough and provisional, to one of the questions that arises when the quantity theory of money is to be applied to the actual commercial world. The other difficulty due to the use of paper substitutes for money has still to be considered, but it will be instructive to apply the knowledge we have already gained without further delay, and so get a clearer insight into the real problem. It is necessary to anticipate one point, however ; the investigation on paper money that will be attempted in the subsequent chapters indicates that some of the increasing demand for money is met by an increasing efficiency in substitutes, so that the demand for gold should be taken to

increase rather more slowly than the world's trade. A rate of  $2\frac{1}{2}$  per cent. per annum will be assumed as representing the increase in demand for gold, and the consequences of it compared with the facts. Of course the rate of progress is not quite constant, but to assume that that average rate has held for the last half-century is perhaps as near an approximation as our knowledge allows of.

The method of comparison is this: a date is chosen as starting point, and preferably a recent date, since the statistics are more trustworthy. January, 1901, has in fact been chosen, partly for the accidental reason that the monetary stock of gold was then as nearly as can be estimated one thousand millions sterling. It is assumed that to maintain a proper proportion to trade this stock must grow at the rate of  $2\frac{1}{2}$  per cent. annually; the required stock at five-yearly intervals is calculated accordingly. The estimated actual stock is then compared with the required stock; the comparison may be made by aid of Fig. 3.

The figure shows that the actual stock was before the Californian discoveries on a lower

scale than our chosen standard requires ; that the large production of the Californian period brought about a redundancy, which was most marked about 1871, more than twenty years after the mines were discovered ; that the demands of trade gradually overtook supply, so that the redundancy was converted into a deficiency in the later eighties and the nineties ; whilst the renewed abundance of the present or Witwatersrand period has again made the actual stock exceed the required.

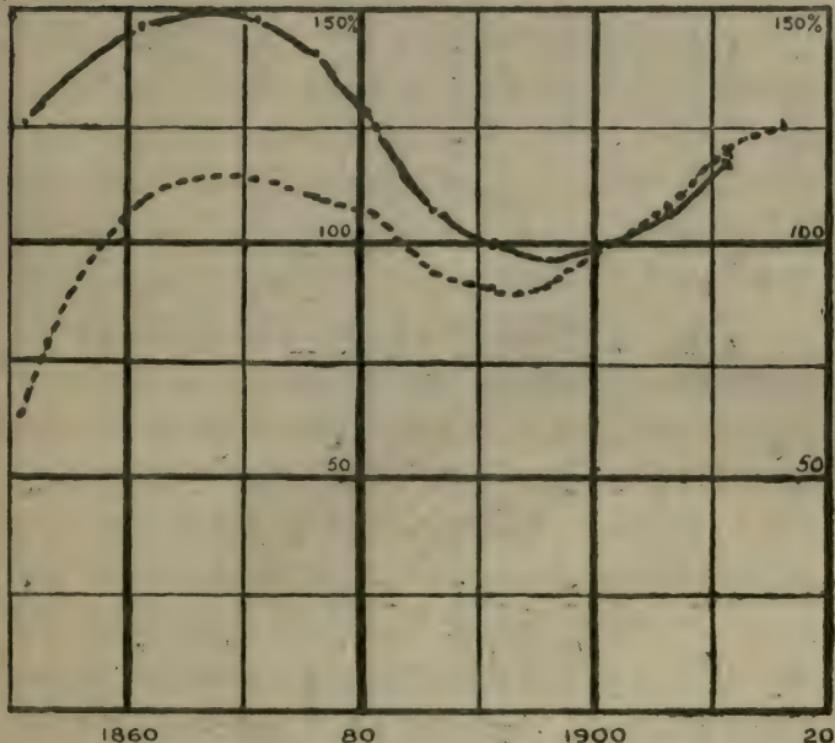
This history obviously accords in a general way with the history of prices during the same epoch, as it should do according to theory. To test the agreement more minutely we proceed as follows : Divide the actual by the required stock. If the quotient is 100 per cent. that shows the supply of gold bears just the same proportion to the demand as it did at the chosen date of January, 1901, and the level of prices ought therefore to be the same. If the quotient is not 100 per cent. it will show in what proportion the supply of gold is greater or less than in January, 1901, and according to the quantity theory the index

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number of prices should be in the same proportion greater or less than the index number for January, 1901.

Fig. 7 shows by the full curve the ratio of

Fig 7



actual to required stock and by the dotted curve the price index. I think no one can examine these two curves without seeing that there is a real relation between them, at

least for the later years. For the earlier years they rise and fall together, but not in the same proportion ; there is however a reason for this. It lies in the circumstance noted at the beginning of this work—the gradual supersession of silver. The actual stock estimated for recent years is correct now that silver has been demonetised nearly all over the world ; but in the middle of the last century to the actual stock of gold should be added a large part of the silver in the world. If this were done the curve representing actual stock as a percentage of required stock would be raised in the early part of its course, but not at the end. This would clearly bring it into closer agreement with the curve of prices. No attempt has been made to carry out this correction numerically, as the statistics are too imperfect, and it is almost impossible to say at any given date what part of the silver stock could be regarded as in the same monetary position as gold. Still there can be no doubt that, making allowance for the use of silver in the earlier decades, the course of prices has been very closely that which should have taken place in accordance with

the quantity theory of money, and that the assumption of  $2\frac{1}{2}$  per cent. as the rate of growth is not far from the truth. A discussion of the bearing of paper money on the determination of this figure will form the subject of the next chapter.\*

\* The method used above, that of comparing price level with the excess or defect of the whole stock of gold, appears to have been first used by *A. Aupetit* ("Essai sur la Théorie Générale de la Monnaie," 1901). It was subsequently used by *Cassel* (*Ekonomisk Tidskrift*, Stockholm, 1904), *R. H. Hooker* (*Journ. Roy. Stat. Soc.*, December, 1911), and *M. Lenoir* ("Formation et Mouvement des Prix," 1913). The earlier of these writers, however, take, not the actual stock of gold, but the total production to date, regardless of the fact that much of it has disappeared; while Lenoir instead of the *ratio* takes the *actual* excess or defect from an assumed normal stock.

## CHAPTER III.

### PAPER SUBSTITUTES.

Paper money and bank deposits as circulating medium  
—Amount available—How far an accurate measure  
—American and other statistics—Definition of  
“ currency factor ” to measure efficiency in use of  
gold—Evaluation of the factor in various countries  
—Tendency to change.—Frequency of sale of goods  
—Tendencies to change of frequency—Effect of de-  
velopment of speculative markets—Of facilities for  
borrowing on produce—Frequency of use of money—  
Irving Fisher's estimates—Tendencies to change  
due to habits, transportation, banking facilities.

GOLD is not the only means of exchange,  
and the next point to deal with is what rela-  
tion exists between the stock of gold and the  
total of currency.

With regard to silver coins it is only  
necessary to remark that they now constitute  
token money (except in China and the neigh-  
bouring countries), *i.e.*, they only pass current  
at their nominal value because some authority  
is willing and able to exchange them at that  
rate for gold. They are, therefore, nearly in

the same position as paper promises to pay. This is true even in three important countries which still hold large stocks of silver coins that are legal tender to an unlimited extent ; these countries are India, France, and the United States. In the latter the coins in question (silver dollars) are not wanted by the people, and so lie, for the most part, a useless burden in the United States Treasury : in France about two-thirds of the *écus* were in circulation, the remainder being held by the Bank of France (in peace-time).

Notes issued either by the banks or the government exist in all countries, and during the war belligerent governments have yielded to the temptation of borrowing by means of note issues, as they have so frequently in the past. The most legitimate use of that resource has been made in England, where the public has been persuaded to accept Treasury notes in place of the large amount of gold coin that was current formerly. This change of habit is an economy of gold precisely to the extent that the issue is fiduciary, *i.e.*, is not covered by a store of gold held by the issuing authority. Nearly £250,000,000 of Treasury

notes are in issue, and nine-tenths of the amount is fiduciary.

In France, Russia, Germany, and Austria, at the present time, despite their large gold reserves, the gold standard is no longer effectively in use, so that the large issues of bank notes stand on a different footing; even in England, though gold reserves have been used more freely, the sovereign has not been kept at par with neutral countries. But to appreciate the situation in normal times we may revert to the reports of the United States' Mint, from which we find that the fiduciary or "uncovered" circulation of paper money in the world (excluding India and China) was at the beginning of 1914 some 737,000,000 sterling. This together with the silver money is an addition of more than one half to the gold stock on which it is based, so that the total money in circulation is estimated as equal to :—

			£m
Gold	..	..	1,615
Silver	..	..	425
Paper (uncovered)		..	737
			<hr/> £m2,777

But, after all, in English-speaking countries,

when we want to make a payment, we commonly employ neither coin nor notes ; we write a cheque for the amount. It has been estimated that, in the United States, 92 per cent. of the amount (not the number) of all payments is made by cheque.

A cheque must not in itself be compared with a coin. A cheque is an order for the transfer of a certain amount of bank deposit from one person to another ; it is merely the instrument that effects the transfer, and is therefore strictly comparable, not with a coin, but with the act of handing a coin from one owner to another. It is true that cheques are occasionally kept by their payees, and handed on to another person, in the same way as bank notes, but such use is rare, and tending to diminish as more and more people keep bank accounts. Moreover, the use of cheques as currency in that way is confined to the smaller ones : cheques for considerable amounts are practically always paid at once into the account of the payee, and serve to liquidate one transaction only.

The valuable which is used for payment is therefore not the cheque but the bank

deposit ; and, in fact, if any one of us stops to think how much money he has available, he at once adds together the coin and notes in his purse, and the amount standing to his credit at the bank. However rich he may be he does not usually consider that he has more funds to pay with than the amount of cash and bank balance added together. If that sum is not sufficient to meet his prospective liabilities he proceeds to make an arrangement with his banker, whereby some of his other wealth is made the basis of an increased bank deposit.

It has been objected that banks will sometimes cash cheques for customers whom they trust, in excess of the amount standing to the customer's credit. In so far as this is done the total of bank deposits is rendered an inaccurate measure of the funds available for making payments ; but such unsecured overdrafts are probably small compared with the total of deposits. Again, a customer may arrange for a secured overdraft, without a special account of the loan being kept, and may not immediately avail himself of the right. In this case also there is a latent fund

available for payment which does not figure in the bank's total of "deposits," but, as a rule, such funds are drawn upon soon after they are secured. As soon as they are drawn upon they are handed on to some one who adds the amount to the funds standing to his credit ; so that, again, the total of deposits measures the *current* resources available for payment. The inactive period during which the original customer has the right to draw and does not use it may be compared with the period that elapses between the digging up of a piece of gold and its first issue from a bank as a coin.

We may then conclude that the funds for payment are represented, fairly closely, by deposits on current account—or what the Americans call checkable deposits (in addition, of course, to coin and notes). Time deposits are not to be included, any more than other securities. There are certain details, such as those affecting foreign bills and postal drafts, which should be considered in attempting to arrive at the most accurate statistics, but it would be of little consequence to touch on them here. It is then of the highest

importance for our purpose to know the magnitude of these deposits.

The banks of the United States are required by law to give a full account of their position, and amongst other details must state their checkable deposits separately from deposits subject to notice of withdrawal. It is noteworthy that the former class preponderates very largely in the National Banks, which are the leading members of the banking system. Thus on June 4, 1913, "individual deposits subject to cheque" constituted 4,866 million dollars out of 5,953 millions of "individual deposits," or 82 per cent. Besides the National Banks there are many others, but these do much business of the savings bank character, as well as ordinary banking. Nevertheless they raise the total of individual deposits subject to cheque to 8,241 millions, at the same date; there are large sums deposited by one bank with another, *e.g.*, by country banks with their New York correspondents; these, however, appear separately in the returns, as they should do. They do not constitute funds that the public can use in payment; to count them in

would be to count the same money twice over.

In England, although banking is most highly developed, the statistics published by the banks are most imperfect. The totals of deposits do not distinguish between money on current account and deposits that can only be withdrawn after notice, and are, therefore, not available as currency. On this important point, one who has not access to confidential information can do nothing better than make a guess. For instance, at the beginning of 1914 the "deposits and current accounts" of English, Scotch and Irish banks totalled £m1,054. Of this, the Bank of England held £m52, and as the bank's business is largely to hold a central reserve on behalf of the other bankers, it will be best to omit this item altogether. It is true that it is not altogether a duplication of other bank's deposits, but there is a small, unknown amount of duplication in the figures published by the other banks themselves; as a working rule we shall leave the Bank of England's deposits out. This leaves £m1,002. Now, if guided by the United States statistics and such general

information as is to be had, we take 60 per cent. of deposits (outside the Bank of England) as "checkable" we get practically £m600. To this, however, must be added something on account of the colonial and foreign banks which have offices in London. The colonial banks alone showed £m405 of deposits, of which it is perhaps reasonable to assume that one-tenth was located in London. The foreign banks also hold large sums there chiefly for use in exchange operations. At a guess we may take £m50 as the current deposits at the colonial and foreign banks in London together, so raising the total to £m650.

In France deposit banking is far less developed. The Bank of France returns some twenty to thirty millions sterling of deposits, a sum insignificant beside its issue of notes. According to the Aldrich report,\* deposits in the chief other French banks in 1903 amounted to £m120 and included some time deposits.†

In Germany banking has progressed more

\* National Monetary Commission of the United States (1909) Report and Statistics.

† The total for France seems too small, and has certainly increased much since the date given.

than in France, although the German banks are very far from being on the same scale as those of England, and the use of cheques is not nearly so widespread as in England. The nine large Berlin banks, shortly before the war, showed total liabilities of £m315.\*

We have then to make the best of an imperfect collection of statistics. Fortunately, two circumstances help to make the statistics more dependable than they appear at first sight ; first, that the best and most complete returns are made in the country which is coming more and more to preponderate in the commercial world ; second, that we are more concerned with the time-changes of the figures than with the figures themselves, and even though statistics are collected on different and imperfect systems, if the publication is continued from year to year, a fairly close deduction can be made as to the rate of change.

Our object is to find how far the various currency devices have been successful in economising gold. With this aim we shall endeavour to work out a currency factor,

\* L. Joseph : "The Evolution of German Banking." Table 5. (Statistics for 31 Dec., 1912.)

defined as follows:—All the currency (or means of payment) actually used by the public of a country (*i.e.*, not belonging to the banks and treasuries) divided by the stock of gold in that country.

As an illustration take the figures for the United States in the year 1909. For the amount of currency we take the calculations of Prof. Irving Fisher, based on the reports of the Controller of the Currency. An estimate is first made of the total stock of money in the United States: gold, silver, nickel, and copper, gold and silver certificates, treasury and bank notes, and clearing-house certificates; from this is deducted the money in the treasury and in the banks (with a calculated allowance for banks that neglected to make returns—a very small percentage). The residue was 1,630 million dollars. To this must be added the much larger sum of "individual deposits subject to cheque" estimated at 6,750 million dollars, giving a total of 8,380 millions (on June 30, 1909). According to the Director of the Mint, at the same date there was in the United States gold coin and bullion to the value of 1,641 millions.

The ratio is therefore 5·1. That is, if the people of the United States wished to conduct all their business with gold coins, using them with precisely the same frequency and in the same manner as they now use coin notes and deposits, they would need five and one-tenth times as much gold as they actually possess. The currency factor is high, in accordance with the high development of the banking system of the country.

It would take too long to give, here, detailed estimates for other countries—estimates which, indeed, would be very imperfect; it must suffice to make some general statements: further information is given in the Appendix, Table XIII. In England the currency factor is as high as, or even higher than, in the United States, owing to the excellent monetary and banking systems in vogue, and the enormous amount of business concentrated in a small area. In Germany the factor is much lower, but is increasing. In France it is lower still: the French people have long distinguished themselves by the possession of an enormous stock of “hard money,” as well as by extreme conservatism and soundness in their business

methods. France is a wealthy country and can afford this luxury if it chooses.

The very rough estimate which alone is possible for the world at large (still excluding India and China) brings out the currency factor as something between 2·5 and 3. What we want to know for the purpose of the present study is, whether this factor is increasing and, if so, how fast.\*

At first sight it might be supposed that the rapid progress of commerce which is noted in all parts of the world would bring with it a rapid advance in the economy with which gold is used. If the currency factor in England is twice as high as in the world at large there is clearly room for great improvement, and it might be expected that other countries would hasten to imitate the methods that in England have led to so great economy. However, national customs with regard to currency are remarkably tenacious. For instance, there is no doubt that France could save half its stock of gold by a proper development of deposit banking ; yet though the Government now does its best to encourage

\* All these estimates refer to peace-times.

the use of cheques, progress is very slow. An estimate of the currency factor, based on figures given in the Aldrich report, brings it out at about the same value—2—in 1903 as a quarter of a century previously (Table XIII.). Again the banking system of the United States suffers from defects which were commonly recognised for several decades before the Federal Reserve Act, which partly remedies them, was passed, and since the resumption of specie payments after the American Civil War was completed, it is probable that the currency factor has never been lower than 4 nor higher than 6. Recently, in fact, there has been such a flow of gold to the United States that the “factor” has fallen rather than risen.

It is in Germany that the most noteworthy progress has taken place, in the rapid development of the large German banks. Germany has never felt it necessary to accumulate such a vast stock of gold in the central bank as France and Russia have done; it has aimed rather at imitating the success of England, which carries on the largest international trade in the world with the aid of a moderate,

but efficiently used, gold reserve. Germany found that its rapidly growing trade could be managed without increasing the Reichsbank reserve in proportion. That reserve was fifty millions sterling in 1901, and only seventy millions in 1913.

Russia has imitated France in accumulating a vast central store of gold ; but there is little in circulation. The trade of the country is increasing exceedingly fast, probably much faster than the gold stock, so that we have here another country in which a progressive economy in the use of gold is observable.

There are countries, however, in which the currency factor is high, not on account of wealth and excellence of banking organisation, but because they have not been able to afford to buy the gold they need. In these cases progress will be in the direction of a fall in the magnitude of the factor, and will consequently set off, to some extent, the rise in other parts of the world.

On the whole, it seems that any change in the currency factor for the world has been very slow ; though the war may possibly make an abrupt change in this matter.

We have not yet come to the end of the causes affecting the demand for money, we have not considered the rapidity with which it is used. There are two allied influences ; the first is, how often the same goods are sold ; the second, how often the same money is passed from hand to hand.

The wheat that springs up in the fields is destined to become bread on the breakfast tables of the people ; how often does it change ownership in the course of this journey ? A piece of iron ore in the ground is eventually converted into a razor ; how many sales are involved before the transformation is complete ?

It is impossible to answer these questions with any approach to precision, still less to arrive at an average frequency of sale for all goods. We can, however, make some attempt to discuss the changes that industrial progress is bringing about. There is an ever-growing elaboration in the methods of production, which makes the number of processes through which goods are passed to increase ; but passing from one process to another does not always imply a change of ownership. If a

cowhide is passed from a farmer to a small local tannery, and thence to a cobbler, the sales may not be fewer than if it goes to a wholesale bootmaking company ; and possibly, the company may set up its own tanneries. There are businesses in existence which, starting from their own coal and iron ore, do all the processes necessary to putting finished steel rails on shipboard for export. It appears then, so far as manufacture is concerned, the growth of machine production may at one stage increase, at another decrease, the frequency of sale of goods manufactured. With regard to the distributive side of production we are, perhaps, more likely to find an increase in frequency of transfer. An elaborate commercial organisation of exporting and importing merchants, factors, brokers, jobbers, and retailers, grows up in connection with each staple commodity ; this has meant an immense growth of commerce as compared with the primitive production of a village community for its own needs. But in the more advanced countries there is some tendency to squeeze out middlemen, so that it is difficult to say what the tendency may be on the whole.

There are two modern developments that certainly tend to increase the frequency of money payments. One is the formation of a speculative market ; when this is fully established—*e.g.*, the Chicago market for wheat—the same goods may be sold any number of times whilst making no manufacturing progress, but only being held for use at a more convenient time. The second is the growth of facilities for borrowing on produce. When goods are exported on a bill of exchange, although the legal ownership of the goods does not change, the bill may be sold a number of times over ; by the grower to his bank, by it to a metropolitan bank, then to a London bill broker, and then to a London bank, for instance.

This leads one to consider the selling of capital goods. The modern development of joint-stock companies, and of the share market, have made the sale of industrial properties infinitely easier, so that there is an immense business done in property rights that hardly existed a hundred years ago.

On the other hand labour, apart from its embodiment in goods, is rarely sold more than

once ; though there are exceptions, as when an actor sells his services to a theatrical company which resells them to the public. But as personal services form an increasing fraction of the whole of employment, this is a small influence tending to reduce frequency of sales.

Turning now to the other side—the frequency of use of money—we are in a better statistical position. The term commonly used by writers on the subject, by the way, is “velocity of circulation,” not perhaps a very happy term. By it is meant the average number of times the money passes from one ownership to another in a year. It is to be arrived at by dividing the amount of any particular class of money into the total value of payments made with it in a year. This is more easily done in the case of bank deposits than in that of gold or notes ; cheques drawn constitute a record of the employment of deposits, and a large fraction of the cheques drawn pass through clearing houses, which at least publish their totals. Estimates of the magnitude of payments made in coin and notes are indirect and much less certain.

The observations of Pierre des Essars in 1895 are amongst the earliest attempts to determine velocities of circulation (the contributor to Palgrave's dictionary, who could not have written much before that date, regards the determination as impossible). Subsequent work by Kemmerer \* and, especially, by Irving Fisher † has carried our knowledge a long way further forward ; but these two writers deal only with the United States. For details of the methods, which are very ingenious, we must refer to the originals ; but the results are important to quote. Fisher finds that between 1896 and 1914 the "velocity" of money in the narrower sense (coin and notes) has varied between nineteen and twenty-two times per year, showing, perhaps, a slight tendency to increase ; while for bank deposits the velocity has shown a notable and pretty steady increase during the same period from thirty-eight to fifty-four times a year. It is important not only to know these num-

\* "Money and Credit Instruments" (New York : Holt, 1907).

† "Purchasing Power of Money" (New York : Macmillan, 1911).

bers, but to understand what causes of change they imply.

If money in the form of coin or notes is used on the average twenty times a year, that means that it remains on the average about eighteen days in the possession of one person. Now it is clear that the extent to which a man lays in a stock of money depends largely on his habits, and his accessibility to banks and markets. The average town-dweller probably keeps by him enough to pay his expenses for a week or two ; he may be paid weekly wages and spend them in the course of the week ; or he may draw enough from his bank to serve as pocket-money for, say, a fortnight. On the other hand a farmer, or anyone to whom it is inconvenient to go into town often, will keep a good deal of money on hand. Accordingly one would expect that as population grows denser, and means of communication cheaper and more rapid, that frequency of use of money will increase. The numbers given above are for the United States ; very probably in Europe the frequency is greater. There must be a limit however to the economy that is practicable, and presumably that limit

has already been reached by the inhabitants of large cities.

With regard to bank currency, we may conveniently deal separately with commercial and non-commercial depositors. A man who lives on a salary, professional fees, or dividends, unless he indulges in speculation, hardly draws any more in cheques than the amount of his income. Since his turnover is thus limited, the only way in which an increase in the frequency of circulation of his deposits could occur is by keeping his bank balance down. If facilities for small investments are improved and the public grows more careful to secure interest on small balances this may happen, and then a smaller amount on deposit will serve to do the same work of payment.

Commercial depositors are in a position to use their resources with varying degrees of activity, according to the way they conduct their business ; but if they succeed in developing a more active business, they are bringing into existence transactions that would not, otherwise, have occurred. Hence they increase simultaneously the use of money and the demand for it. In this case too, then, the only

way of obtaining an increase of frequency which will really economise money is to conduct business on a narrower margin of balance at the bank. How far this tendency can go depends chiefly on the policy of the banks themselves. It would be interesting to know whether the American banks are inclined to allow customers to work within a smaller average balance in proportion to their daily turnover than they used to ; also whether the custom of allowing unsecured overdrafts is more widespread than formerly. On all such points practical bankers might give valuable information if they are not debarred by a policy of secrecy.

Some limit to narrowness of margin is inevitable. A broker in a great city whose transactions are nearly all with persons having banking accounts in the same city may perhaps manage with an average balance equal to no more than two days' transactions ; in that case the velocity of circulation would be about 150. But a merchant dealing with persons at a distance and receiving payments somewhat irregularly, could hardly be content with so little. The change which Fisher notes as

having taken place in the United States during the last two decades may then ultimately be referred to increased facility of communication ; it may therefore be expected to continue for many years to come, but not to an unlimited extent.

## CHAPTER IV.

### INFLUENCE OF THE WAR.

Summary of influences tending to increase in demand for, and to economy in the use of gold—Effects of the War—Increased demand for certain goods—Hindrances to supply—Consequent revaluation—Inaccuracy of the customary index numbers—Inflation of currency—Statistics—Gold has fallen in value because the demand for it is less than in peace-time—Analysis of the demand—Redundance in America—Policy of Sweden—Prospects after the War.

BEFORE proceeding to consider the present situation we must summarise the results of the last chapter. We found the following causes tending to make the gold supply of the world become more effective as time goes on :—

- (1) The spread of the custom of using cheques, especially on the Continent of Europe.
- (2) The development of a more efficient banking system in the United States.
- (3) Tendency to combine manufacturing processes of different grades, and manufac-

turing with merchanting, under a single business, and associated tendency to eliminate middlemen.

(4) Increasing importance of personal services as compared with work spent in producing goods.

(5) Increasing frequency in the use of money, due to denser population and improved means of transport.

(6) Care over investment of small sums, and consequent cutting of bank balances to a minimum.

On the other hand are causes which increase the amount of work the gold supply has to do, or which make it less effective :—

(1) Desire of nations in a weak financial position to strengthen their gold reserves (*e.g.*, Brazil).

(2) Increasing elaboration of productive processes, and greater use of raw material from a distance.

(3) Development of speculative markets in raw materials.

(4) Increased facilities for borrowing on produce.

(5) Increased marketability of business

capital through organisation into limited companies.

It is clearly almost impossible to make a quantitative estimate of all these factors ; all one can say is that the first group probably prevails over the second—numbers (1) and (6) being the most important. The striking conclusion is, that all these causes between them produce much less effect than the supply of gold and the growth of trade ; in other words, the quantity theory of money, as it would be if there were no money but gold, is but slightly modified by the circumstances of the modern commercial world. If it is true that the economising group of influences prevails, then the situation is the same as if the rate of increase of trade were somewhat less than it actually is. Now in the second chapter it was concluded that the rate of increase of trade is about 3 per cent. per annum ; but a rate of  $2\frac{1}{2}$  per cent. was subsequently adopted as expressing the rate of increase in the demand for gold. The justification for this lies in the arguments which have now been summarised ; the correctness of the estimate is confirmed by the agreement which was noted between

the course of prices and the stock of money metal.\*

It should be unnecessary to repeat here the deductive reasoning on which the quantity theory is based, and which is to be found in all the treatises on economics; but it has sometimes been objected to the theories that they do not sufficiently explain the mechanism by which a change in the amount of money affects prices. A suggestion of this in the case of a primitive community, using metallic money, has been given already; that of the miner with gold dust in his pocket, but in want of a pair of boots. It is, however, more interesting to consider the action in a developed commercial country. If there is an influx of gold into a certain country, the first holders of it usually are the banks. As bankers are in the habit of regulating their offers of credit

\* If Fig. 7 be drawn with the "required stock" increasing at rates of  $2$ ,  $2\frac{1}{2}$ ,  $3$ ,  $3\frac{1}{2}$  per cent. in turn, it will be found that the lowest and highest rates yield curves that depart excessively from the price curve. Between the curves for  $2\frac{1}{2}$  and for  $3$  per cent. it is not altogether easy to decide, but, on the whole, the preference is with  $2\frac{1}{2}$  per cent. In any case the conclusion holds, that there was (before the war) only a very slow change in the currency factor.

in pretty close proportion to their stocks of gold, they will wish to extend their loans ; there will be a period of easy money, and there may be a fall in the rate of discount. This makes traders generally anxious to seize the opportunity of doing increased business ; they make speculative purchases, especially of raw materials, which raise the price of the goods bought. The rise cannot be restricted to certain classes of goods, however it is bound to spread. For all the persons who sell at a higher price have more money to spend, and will therefore come into the market for such goods as they choose ; but though there is more money to buy with, there are no more goods for sale (the incoming of gold does not increase the stock of food, of houses, or manufactures), and the inevitable effect of this is a rise in price. One of the most easily recognised instances is the demand for houses, pictures, motor cars, and so on, that springs up when a number of people have made money by speculation. The rise spreading to retail prices and wages, will call for more coin in circulation, and if the increased supply of gold stops, this will stop the rise, as the demand for

circulation will deplete the bank reserves. But if the inflow of gold continues the rise in prices will continue. The process has been in full swing recently in America, where the banks have been receiving so much gold from Europe that the extension of credit and rise of prices seems to have alarmed them.

We have now to try and get a conspectus of what has really happened during the war. It was pointed out above that when the price of a commodity changes, the cause of the change may be in the commodity or in money ; but that a change in price, common to many different articles simultaneously, cannot usually be expected to have its origin in the commodities. War makes an exception, for it makes production of all kinds more difficult. This is due to the withdrawal of skilled labour and enterprise, as well as of capital, for the new occupation of fighting, and its subsidiary trades, such as munition making ; production of staples such as foodstuffs and ordinary manufactures is rendered more difficult and, at the same time, the needs of the army increase the demand for food, clothing, steel, and other goods. The combination of in-

creased demand with more difficult supply naturally raises values ; it is, however, important to be clear as to the meaning of such an expression.

Value is a mere relation ; the ratio of exchange between different things. A universal rise in values is, therefore, nonsense ; as much so as saying that two men have grown so fast that each has grown bigger than the other. If there has been a rise in value common to a large number of things, there must be other things that have fallen in value. In the case of war we unconsciously take average labour as our standard of value, and really imply that labour of all grades has on the whole fallen in value ; that wages have not kept pace with the increased cost of living. This is an inevitable consequence of war. Further, most capital goods have fallen in value and notably bonds and shares.

In ordinary circumstances index numbers based on the price of raw materials form a generally trustworthy, though not perfect, measure of the relation of values to money. In war-time this is not true, because such index numbers are not widely enough based.

and the whole group of prices from which they are calculated has suffered a shift relatively to wages, and capital goods, which are not included in the calculation. We may, therefore, conclude that the observed rise in the usual index numbers is partly due to general scarcity and difficulty of production, without falling into the fallacy of positing a universal rise in values.

Only partly, however. A great deal of the rise is due to inflation of the currency. When war breaks out every one wishes to have as much cash in hand as possible, so that all sorts of steps are taken to increase the currency—the English Treasury notes are an example. If the war is long the public gets used to it, and the financial crisis passes ; but the extra currency that has been issued is not withdrawn, for that would be equivalent to paying back a debt, and war is not a time for paying debts. On the contrary, governments, pressed for money, nearly always yield to the temptation of inflating the currency further, as a means of raising funds. Neutral countries do not escape, for the rise in prices in belligerent countries causes gold to be

exported, and the stock in neutral countries being thus increased, their bankers increase credit, and the rise in prices thus comes to extend all over the world.

These facts have long been known to economists, and can be read in standard treatises ; what is new, is that one of the belligerents, England, has, in the course of the three years of war, grown partly aware of them. Whereas the banks were encouraged to subscribe heavily to the second war loan (of 1915) with the consequence of adding to the inflation of currency, they seem to have regarded it as a duty not to subscribe to the third loan (of 1917).

It is too soon to make a quantitative estimate of the inflation due to the war. All that one can do at present is to give illustrations of it. The inflation has taken two forms, increase in paper money, and in bank deposits. With regard to the former, we have already remarked on the use of Treasury notes in England. They have been issued to the extent of about £250,000,000, and at the same time the Bank of England notes in circulation have increased by some £20,000,000 above

the pre-war amount. Against this has to be set a considerable withdrawal of gold coins from circulation ; the amount is not known with any certainty, but it is supposed that about £100,000,000 was held by the public and the banks other than the Bank of England. Sovereigns are now hardly seen in England ; so, if we suppose the whole of that amount to have been withdrawn, there remains a balance of £179,000,000 increase in circulation.

This increase appears trifling when compared with that in other countries. In France the banknote circulation in April, 1914, was £238,000,000 ; in July, 1918, it was £1,158,000,000, or an increase of 920 millions sterling. In Russia, June, 1914, the note circulation was £185,000,000 ; in February, 1917, £920,000,000, or an increase of 735 millions sterling. Under the revolutionary governments the increase has been enormously greater. These amounts will be difficult to "digest" after the war ; moreover, they are still increasing fast. Germany, despite the common opinion to the contrary, has been more careful in its finance ; still note circulation of the Imperial Bank has increased

from £95,000,000 to £625,000,000 (July, 1918).

If England has been modest in the issue of notes, that is largely because cheque currency is more important; the figures of bank deposits show far too great an increase. Thus the nineteen chief banks give these figures:—

				£m
June 30, 1914	..	..	..	747
"    1915	..	..	..	943
"    1916	..	..	..	987

This increase is not a healthy one due to increasing real wealth, for before the war the annual charge was only twenty to thirty millions a year; there has evidently been an enormous artificial extension of credit, chiefly, in the first instance, in the form of loans to the Government.

Again, the New York Associated Banks return deposits of:—

				£m
July 1, 1915	..	..	..	524
"    1916	..	..	..	688

and although the United States has been making vast profits out of the war, the extension of credit has undoubtedly gone beyond

them. All this extra currency has doubtless contributed largely to the rise of prices—a rise that is less marked in South Africa than in most countries, though even here it is sufficient to attract general attention.

The fact is that gold has been depreciated by the war, because the demand for it has fallen off. Some readers may suspect paradox in this statement ; it is, however, nothing more than straightforward common sense.

The demand for gold—let us say in England, to fix the attention—may be divided into three parts ; it is wanted for use in the arts, for internal currency, and to regulate foreign exchange. The first demand has undoubtedly fallen off, the uses of gold in the arts being such as can conveniently be spared in time of need ; and, indeed, the Government has practically forbidden it, by making it illegal to melt coin. The second demand, that for circulation in the country, has disappeared altogether ; this is a psychological change, the public having been persuaded that it is patriotic to use paper money instead. The third demand remains, and a large amount of gold has been used for exchange purposes ; but it is a mis-

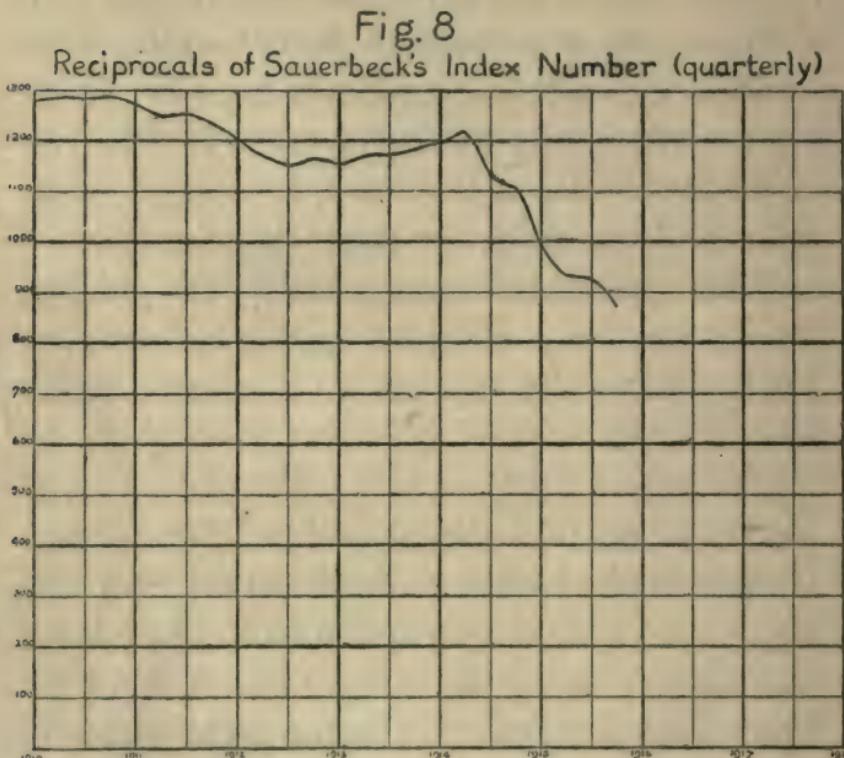
take to suppose that this one demand, though abnormally great, exceeds the three demands that existed previously. If this is the case in England, which has sedulously kept the foreign exchanges about par, what is the case in France, Russia, Italy, Germany, and Austria ? They have all given up gold circulation ; the gold-using industries are far from flourishing in any of them ; indeed, appeals are made to the public to melt down their jewellery for coinage ; and none of these countries has paid any serious attention to foreign exchange ; they have all let their currency be depreciated. Is it not clear, then, that the demand for gold has almost ceased ? and that it can only be disposed of by offering it to neutral countries ; and they show a decided unwillingness to take it.

Probably no one will maintain that America shows any keen demand for extra supplies of gold, and America has been by far the most important of the neutrals ; but events in Sweden are even more instructive. The National Bank of Sweden usually buys gold at par ; in other words it accepts gold coin and bullion, and credits the depositors with the

value in its books, in the same way as the Bank of England does. But owing to the excess of Swedish exports over imports during the war, so much gold has been presented that the Swedish Bank finds it unprofitable to hold any more and now refuses to accept any. The result is that Swedish currency is no longer on a gold basis ; but not in the sense that is true of the currencies of France or Germany. The franc and the mark are depreciated relatively to gold which is not obtainable by the public ; but in Sweden it is gold that is depreciated relatively to the currency. Sweden realises that to accept more gold would only be to accumulate a useless stock, and to suffer the disadvantage of a rise in prices. She refuses it accordingly, just as a merchant might refuse to accept pig iron in payment of debts, if he had already a larger stock of iron than he knew what to do with. Of course the amounts dealt in by Sweden are small ; the action is none the less worth pondering over.

Fig. 8 shows the course of prices in the same way as Fig. 5, that is by the reciprocals of Sauerbeck's index number ; only as the period covered by the diagram is short, instead of

decennial averages, the numbers for each quarter, as published, are taken. The figure must be read with the proviso already explained, that the real value of raw materials



has risen, so that the depreciation of gold is exaggerated ; despite this it is genuine and striking enough.

What can one say of the future, after the war ? No doubt the demand for gold will

revive. The continental nations will want to restore their currencies to a gold basis ; and for that purpose will strengthen their gold reserves ; but to some extent the restoration will come about of itself through the cessation of war purchases. If the habit of using paper money persists in England, France, and Germany, as may quite well be the case, now that people have got used to doing without gold, the banks may not need much after all. Put in the form adopted in the last chapter this would mean an increase in the currency factor ; the factor grows very slowly in ordinary times, but it may suffer a sudden shift as a legacy of the war.

It is little use speculating on the precise action of the nations after the war, but it is of consequence to realise that there are limits to the demand for gold ; or rather to understand precisely the sense in which alone the demand is unlimited. It has been stated by a responsible person that if the Rand turned out a hundred million pounds worth of gold a year, the world could absorb it. This is only true in the same sense that if the output of zinc or of rubber were doubled the world could absorb it.

Every one realises that in the case of other materials a greatly increased supply could only be absorbed by a fall in value. Gold serves the purpose of facilitating the world's exchanges. If there were more gold there would be no more use for it (not counting the uses in manufacture); it would still do the work of exchange and nothing else, whereas an increased supply of zinc or rubber would serve new utilities. How can it be expected that if there be a larger supply of metal, with no more useful work for it to do, that the value should not fall? If gold became as abundant as silver, no doubt it could all be used for currency purposes, but it would fall to something like the value of silver.

Further, if the value of gold were to be forced down by over-production, so as to bring about a revolutionary change in its value, the nations might object to using it as a standard of value, just as Sweden has done.

## CHAPTER V.

### POSITION OF THE WITWATERSRAND.

Gold supply—Relative importance of the Rand—Characteristics of mining on the Rand—Analysis of working expenses and effect of rising prices—Cost of living on the Rand—Labour prospects—New mining areas on the Rand, geological expectations, and probable influence on the older mines—Problem of a stable money standard—Irving Fisher's proposal—Alternative solution suggested in the form of international control of gold output and conservation of resources.

ATTENTION was called in the first chapter to the increasing share that the Witwatersrand is coming to take in the gold production of the world. The share of the Transvaal (and the outlying mines contribute only a minute part) has risen to more than 41 per cent. The Witwatersrand still contains vast untouched stores of gold-bearing rock, whereas in other parts of the world future resources are not so certain. The Australian output is definitely falling off, indicating a tendency to

exhaustion, at least of the more payable ore. The same is true of some of the American deposits, although the opening up of others, particularly of low-grade alluvial in Alaska, made available by modern improvements in working, keeps up the total. Mexico and Siberia may, perhaps, show important developments in gold mining, but there is no doubt that taking the world as a whole, outside the Rand, there is a lack of present elasticity in the yield.

On the Rand itself, according to current geological opinion, and the evidence of bore-holes and prospecting, the output could be increased almost indefinitely if sufficient capital were provided; though, of course, that is not to say that it would be profitable to do so. Mining in the blanket formation that characterises this field is far more regular than in the alluvial or the quartz deposits found elsewhere.\* There is risk, of course, but not more than in the mining of base metals, nor even much more than in manufacture or transport. Gold mining on the Rand, in fact, is an industry rather than a gamble; and it

\* Lehfeldt: *Econ. Journ.*, vol. xxii., p. 487 (1912).

is one conducted on a large scale. Capital running into millions is needed, and it takes some years to develop a new deep level mine ; but it is impossible to make a fairly close estimate of cost and yield, so that the economic results, not, perhaps, of the single mine, but of the field, are calculable.

In fact, gold-mining comes, for the first time, into the normal economic categories. Alluvial and quartz mining has always been so speculative that no clear connection between cost of production and return could be predicated of it. Thus Soetbeer expresses the opinion that more has been spent on prospecting for gold than the product is worth ; and de Launay says, “ (the gold output) is far higher than it should be in view of the rare occurrence of gold in the earth’s crust, if man did not throw himself upon gold ores with more persistent and exaggerated enthusiasm than, for instance, on iron ores.” But a large and approximately known deposit, such as that of the Rand, influences production in the same way as in other industries ; with a fall in working costs (*i.e.*, a rise in value) the margin of production is extended, and *vice versa*, so

that there is a reservoir, steadyng the value of the product.

It would be very desirable to have some knowledge of the extent of this reservoir ; but, whatever may be known to the heads of the mining industry, little has been published. It is, however, clear that there is a great deal of rock that is auriferous, but not sufficiently rich to be worth mining at present ; so that a reduction in working costs may result in a considerable enlargement of output. What is needed is an estimate of the quantity of ore of each grade of richness. Thus if the normal working cost on a large well-equipped mine is at present such that six grams of gold per ton will cover it, how much more ore would be available if working costs were lowered to the equivalent of five grams ? Probably, the increase would be much more than one-sixth —it might be two, three, or four-sixths ; the question is one of the most important with regard to the future of gold.

Working costs on the Witwatersrand mines are divided into three main groups : stores, white wages, and native wages. The relative importance of these may be judged

from the following figures, which are for 1913:—

Stores .. .. ..	£10,580,000
White wages .. .. ..	6,656,000
Native wages .. .. ..	5,602,000

Of stores, the most important that are purchased oversea are machinery, belting, steel, zinc, timber, candles, and cyanide; while those bought in South Africa include food-stuffs (for native labourers)—chiefly meat and maize—coal, lime, and explosives. The imported stores amount to somewhat more than half of the total value. The expenditure and, where possible, the quantities are recorded by the Transvaal Chamber of Mines, so that the average price of a good many articles can be worked out. Table XV. in the Appendix gives the result of such a calculation for all the articles, which come to more than a hundred thousand pounds a year.

Of imported goods steel and cyanide were nearly stationary in price before the war, but have risen since. Zinc and timber were rising slowly before the war, and the rise has been accelerated by the war. Candles have fluctuated irregularly. Explosives, which are made

locally, remained practically unchanged up to the end of 1915. Coal showed an important drop in price in 1912, owing to a reduction in railway rates. Lime has grown cheaper, no doubt partly for the same reason, but also on account of the discovery of better sources of supply. Local foodstuffs have fluctuated irregularly, and show no tendency to rise.

On the whole, in a period of rising prices, such as that from 1908 on, the record is one of remarkable economy. The mines have suffered but little from the rise in prices during the war; whilst the price of many commodities in Europe has doubled, working expenses on the Rand have risen no more than five or ten per cent.\* The reasons for this are, firstly, that local stores have remained cheap—in fact some local goods have fallen in price owing to the difficulty of exporting them; secondly, old stores, especially of machinery, piping, etc., have been drawn upon to an abnormal extent, and new purchases have been put off; thirdly, with regard to such purchases as have been indispensable, the mines

\* Somewhat more in 1918. Cost of living in Johannesburg has risen about 25 per cent. above pre-war prices.

appear to have obtained some effective favour from the British Government, which was anxious that the gold supply should be kept up. All these influences are clearly temporary, and while they may protect the mines during the abnormal circumstances of the war, will not save them from having to pay higher prices when it is over.

With regard to longer period effects, one seems to be observing a struggle between improved efficiency and rising world prices. The engineers are constantly endeavouring to improve methods, and one cannot suppose that their efforts are fruitless. The efficiency of native labour has increased ; that of white labour probably has not, for the class of skilled Cornish miners, on which the Rand used to rely, no longer goes there ; the white workmen are mostly South Africans, and have not yet developed the skill of the Cornishman. But attempts are being made to remedy this by technical instruction, and the heads of the industry are coming to realise the importance of being on good terms with the workmen.

On the whole a fairly steady improvement

in efficiency may be looked for ; and the improvement extends, no doubt, to subsidiary industries, of which the manufacture of explosives is the most important. It may be possible to effect economies by making, locally, materials that are now imported ; it is even mooted to start a steel industry, based upon local ores, though whether this could compete successfully with international supplies in peace-time is doubtful.

In the early days of any goldfield, prices there are high. This was true even of the Witwatersrand, though communication with it was never so difficult as with the earlier discovered mines. The actual cost of foodstuffs, machinery, and other necessaries was high on account of the difficulties of transport ; and though at an early date most of the gold was sent regularly to London, enough was current locally to create abundant means of exchange. Gold dust was not used for this purpose as it used to be in California, and even in recent times in the Klondike, but a mint was set up in Pretoria, and quite early, banking facilities were carried to Johannesburg, so that indirectly the abundance of gold produced its

effect, and a tradition of high prices, and also of extravagance, was established that has not quite died away, even now.

But as time goes on, prices in a gold-mining centre subside, till there comes to be no appreciable difference from the world at large. Good railway and steamship services are provided ; growth of population brings diversity of industry ; many requirements are met locally, especially in the way of food production, and, on the other hand, as all the gold is exported, and only so much specie imported as is needed by ordinary commerce, the currency situation becomes indistinguishable from that in other industrial regions. All this has happened on the Witwatersrand, and the cost of living there is now not higher than in many other places. It is true that an economic commission sitting in 1913 found prices to be a good deal higher than in England, but the difference from America and Australia was not very marked, and is probably smaller now, since South Africa has been little affected by the war.

Labour on the mines, and such stores as are produced locally, are, of course, influenced

rather by Johannesburg prices than by prices in the world outside. So long as local prices were higher, there was always opportunity for economy in reducing them ; and much of the reduction in working costs on the mines which occurred between the first working of the field and about 1908 may be attributed to that. Cost of living in Johannesburg was falling, while that in the world at large was rising. But now that there is not much difference between local and world prices, this source of economies has vanished. Henceforward it must be expected that local prices will follow more or less closely the trend of prices in the rest of the world.

In harmony with this view, we find from the statistics of the Chamber of Mines that wages of white workmen are practically stationary. The average cost, per head, to the mines between 1908 and 1915 fluctuated between £272 and £284 per annum, without any definite tendency to rise or fall. It must be added, however, that the mines have lately had to pay for the prevention of miner's phthisis more than half a million a year, as well as to take various precautions for dust-laying and

other hygienic measures ; these things are indirectly equivalent to a rise of wages.

Kaffir wages have actually risen in money, from £25 to £29 in the same interval. Moreover the cost of food supplied by the mines has risen from £3 $\frac{3}{4}$  in 1908 to £5 $\frac{1}{2}$  in 1915. Better accommodation and medical attendance is provided also, so that effectively wages have risen quite 20 per cent. This, however, has been balanced by increased efficiency of the native labourers.

The net result of these various influences is that for eight years working costs on the mines were practically stationary, as the table on p. 90 shows.

The unit adopted for these statistics—the ton of rock passed through the mill—is not altogether satisfactory, as it is subject to variation according to the technical conditions of mining, *e.g.*, a machine driller may take out more rock from the same stope than a hand driller would ; he secures a little more gold in consequence, but not in proportion to the weight of rock, while the whole weight has to be shovelled, trammed, and hoisted. It is customary to adopt such a unit, however,

in order to discriminate between the financial effects of a change in the richness of the ore and a change in the efficiency of working. The steady falling off in richness, seen in the

### WITWATERSRAND GOLD MINES.

Tons milled (000 omitted).	Per ton milled.						Divi- dends as per cent. of product.	
	Gold produced.		Working costs.		Dividends paid.			
	s.	d.	s.	d.	s.	d.		
1908	18,197	31	5	18	0	9	7	29.5
1909	20,544	28	11	17	1	9	3	32.0
1910	21,433	28	6	17	7	8	6	29.8
1911	23,888	27	11	18	0	6	9	23.2
1912	25,486	29	0	18	8	6	6	22.4
1913	25,628	27	9	17	11	6	8	24.1
1914	25,702	26	6	17	1	6	6	24.5
1915	28,315	26	4	17	7	5	5	20.6
1916	28,525	26	8	18	1	5	1	18.5
1917	27,252	27	1	19	2	4	11	17.5

table, makes the comparison of working costs a little difficult, but it is clear that to take the cost per ton milled is to put the matter in a favourable light when the industry is being extended by means of the working of poorer ore. If working costs were taken as a per-

centage of the gold produced, they would appear less favourably.

“Working costs,” as published, are not complete ; there are also certain charges regarded as exceptional, such as the payments on account of miner’s phthisis, and also certain capital charges.

Strictly speaking, the cost of working the mines must be taken to include all the value of the output, less the dividends, debenture interest, and profits tax \* paid. Debenture interest is a very small amount and is here neglected. But the figures for dividends paid still present too favourable a view of the success of the mines, as mines do not last for ever, and an allowance out of profits ought to be made for amortisation of capital expenditure. There are not sufficient data available for estimating this allowance accurately, but taking it into account as well as one can, it

\* The item of profits tax may or may not be included, according to the view taken. It was an exceptional tax, but it is of the nature of an income tax and has now been assimilated to the general South African income tax. It amounts to about 8 per cent. of the dividends (in peace-time), so that if it be included, the figures given in the text for percentage cost of working must be increased by 2 or 3.

may be said that the true cost of working the mines of the Witwatersrand has risen from about 71 per cent. in 1908 to 80 per cent. in 1915.

The prospects of this minefield, as estimated by the mining engineer, depend on the grade of ore available, as compared with the capital outlay and cost of working ; the costs being taken according to current experience, some allowance being made for improvements in technique and increased efficiency. This treatment, however, is not complete, as it does not take into account probable changes in the value of money, with their consequent effect on the cost of labour and supplies for mining. The margin between cost and yield is not large in many of the mines, so that the effect of changes in the value of money may easily be important.

After the war it is to be expected that prices will drop rapidly, as the difficulties in agricultural production and transport are overcome. But so far as high prices are due to currency inflation, they can only come down in one of two ways ; either the inflation must be reduced by the Government contracting

loans wherewith to redeem paper currency—a heroic measure that is not likely to be undertaken ; or else the commerce of the world must slowly grow up to the level of the inflated currency. If, for example, the inflation by the end of the war amounts to 50 per cent. and the rate of increase in commerce were 3 per cent. as calculated in a previous chapter, it would take fourteen years for the demand to overtake the supply of currency, even supposing that no further addition was made.

Meanwhile prices would be high, and it seems too much to expect that the mines of the Witwatersrand should escape the effects. Despite any economies of management therefore, one may expect the margin of profit to be reduced still further, and the position of the poorer mines to become unfavourable.

There has recently been an agitation in favour of opening up new mines. It is necessary to look ahead in this matter, as a new deep level mine takes some five to seven years to bring to the producing stage.

The older mines of the Witwatersrand

stretch in a narrow belt eastwards and westwards from Johannesburg ; at the eastern end the belt widens out into an immense area of auriferous ground, known as the "Far East Rand." It has an extent equal to the area of 100,000 claims,\* and it is supposed that payable gold reefs, not too deep for working, exist through most of this area. Over the greater part only prospecting by boreholes has been made ; only in the north-western corner near the Kleinfontein, and in the south-eastern corner near the Nigel, is mining in operation. The rest of the tract—from the mining point of view, vast—awaits exploitation.

Much the larger part of the Far East Rand is, so far as mining rights are concerned, Government property. According to the law as it stands, Government can offer their claims, in suitable blocks on lease ; the lessee is required to put up the necessary capital, and to pay to the Government, as rent, a percentage of the profits. One mine is now working under such a lease—the so-called "Government Areas" mine, the lessee being

\* A claim is equal to 5,948 square metres.

the Johannesburg Consolidated Investment Co. In this case the rent is arranged according to a rather complex sliding scale, designed to give the Government a larger share should the mine turn out to be rich than if it be poor —as is just. An area of 1,812 claims next to the Brakpan and a small group of 651 claims on Modderfontein have just been leased, on different terms.

The South African Parliament, in the session lately closed, appointed a select committee to consider the Far East Rand generally, and especially to advise whether modified terms of lease should be introduced. The committee had before it an important special report by Mr. R. N. Kotze, the Government Mining Engineer.\*

Mr. Kotze puts forward the opinion that outside the boundaries of existing producing companies there are 73,988 claims where the reef lies less than 5,000 feet from the surface ; while, if it be considered that mining to a depth of 7,500 feet is practicable, 19,249 claims are to be added to the number. A modern

\* Memorandum on the Far East Rand (Cape Town, 1916). 22 pp. 2s. 9d.

large mine is usually constituted of some 2,000 claims on an average; so that not less than forty new mines might be staked out.

The reef in the Far East is “patchy”; but, so far as experience goes, the richer patches are large and comparatively easily traced out. If this is so, the poorer patches can be avoided, and mines can be laid out with more prospect of success than when rich and poor streaks alternate a few yards apart; for in the latter case there is nothing for it but to work through both. Allowing as best he can for the geological circumstances, Mr. Kotze concludes that there is an average of 9,000 tons of payable ore per claim, and that this ore may be taken as containing about £1.375 worth of gold per ton.

Assuming these data to be correct, it is possible to calculate the prospects of an average East Rand mine. Working costs fall as the size of a mine increases, so that to obtain a certain standard of success a certain minimum size and scale of working is indicated. In endeavouring to find the minimum the Government mining engineer lays down a

noteworthy standard of the results which he thinks necessary to induce capitalists to undertake a new East Rand mine; the standard is, that the mine should pay 15 per cent. for twenty years, in addition to such dividend as, accumulated at a low rate of interest, will restore the capital at the end of the twenty years, which he assumes as the working life of the mine. He adds the remark: "This may seem high, but, considering the risks run, such an expectation is by no means an unreasonable demand."

A good deal has been made of a statement by the Government mining engineer as to the mines which are expected to be exhausted in the next few years. Mines whose production in 1913 was £9,900,000 worth of gold have "lives" officially estimated to end in 1924 or earlier. This statement is open to misconstruction. In the first place the official life—estimated for the purpose of the profits tax—invariably proves to be shorter than the actual. Next, the output of many of the working mines will probably be increased by extensions of plant. Hence it is not a legitimate deduction from Mr. Kotze's

figures that the output of the Rand will be reduced by 25 per cent. in 1924. At the same time it is reasonable to think of opening up new areas, since a new deep level mine takes so long to prepare.

Conditions on the Far East Rand are sufficiently uniform to make it worth while to calculate the expected yield of an average mine. A recent calculation, reproduced in Appendix B, based on the geological and engineering data from Mr. Kotze's report, brings out two chief points. The first is that, assuming a reasonable rate of interest (4 or 5 per cent.), the most profitable rate of working of a large East Rand mine is that which will exhaust it in twelve to fifteen years: that is to say, the excess of yield over cost, discounted so as to give the "present worth," is at a maximum when the life of the mine is of about that duration (from the time of starting crushing operations onwards). The second point is, that a mine with ore worth £1.000 to £1.200 per ton (eight to eight and a half grammes) is of practically no value, but that the "present worth" rises rapidly as the richness of ore increases, so that, if the esti-

mate of £1,375 is to be relied on (and it is made very conservatively), there are larger profits to be made.

There can be no question that the right policy with regard to a single mine is to work it out on strict commercial principles, *i.e.*, in such a way that its present worth is a maximum. Allowing for the uncertainty of estimates, and for the fact that shareholders like an investment that offers a reasonably long period without disturbance, the assumption of a twenty years "life," made in the report of the Government mining engineer, is a fair one. But it does not follow that a whole mining field should be treated in the same way.

The reason for the difference is the danger of over-production ; in other words, it is the influence of changes in price level. If it were not for that, then the right policy would be to raise some fifty millions of capital, exploit all the known auriferous area at the highest speed, and throw on the market a supply of gold that Mr. Kotze estimates, very conservatively, at £450,000,000. Such a policy would be absurd ; and the absurdity is the logical

condemnation of the error of ignoring changes in price level.

If, after the war, prices remain at a higher level than before, as we have seen to be probable, then a policy leading to a considerable increase in the gold output would make the matter worse. It would tend to exaggerate the rise in price level ; and though it is possible that the new mines on the Far East Rand might still remain good investments, if the geological prognostications are sound, yet the rise in working costs would damage the older mines, many of which have a very narrow margin of profit. Such a policy would be short-sighted even in the narrowest commercial sense. Considered from the point of view of the Witwatersrand community, and of South Africa as a whole, it would be disastrous ; and as the Far East Rand can only be developed with the consent of the South African Government, which is the chief landowner there, it is unquestionably the duty of the Government to see that the prosperity of the whole is not sacrificed to the selfish interests of the promoters of particular mines.

The rapid exploitation of the Far East

## POSITION OF WITWATERSRAND 101

Rand at the present time is equivalent to selling the gold it contains on an unfavourable market. But prices do not continue to rise indefinitely. All minefields become exhausted in course of time, and when the present producers fall off, the value of gold is likely to rise again, as it did when the Californian and Australian fields began to fall off in yield and the Witwatersrand had not been discovered (see Fig. 1). In fact, as the world gets more thoroughly explored the discovery of a new and vast store of gold becomes more improbable. Unless such a discovery is made, or some new process for producing gold very cheaply is invented, or a change in public sentiment leads to the abandonment of gold as standard of value, ultimate appreciation of gold is certain.

If then, for convenience of argument, we suppose the whole of the Witwatersrand to belong to a single company, with no motive but to get the greatest commercial advantages out of it, the owners would see that the exploitation was conducted at a steady rate, not so fast as to cause the product to depreciate seriously, nor so slow as to postpone realisa-

tion longer than could be helped. The precise interpretation of this general rule is difficult, but it is probable that it would lead to a rate of working not exceeding that of the present day, and would conserve a great part of the untouched resources of the Rand for the future times when gold would again have become more valuable.

But as the course of exploitation rests with the Government of the country, other motives must be considered. It is true that if the Government were perfectly wise, and paid as much regard to the future as to the present, it might be argued, on the lines of Ricardian theory, that its action should be the same as that of the imagined company ; the maximum wealth would be secured by this policy and could then be devoted to the permanent development of the country.

It is, however, not much use discussing the policy of a perfectly wise and foreseeing Government. Governments in real life show only too strong a tendency to sacrifice the future to the present, by raising loans to meet any difficulty that arises. A Government that bears the responsibility of developing a

field that contains in gold probably more than the present capital value of all South Africa and everything in it, may well be advised to be conservative. The movement for the conservation of natural resources, of which so much is heard in America, and which has gained some notice in connection with English coal, is a movement to work those resources, not on commercial lines, but as if the rate of interest were lower than it is. The economic argument (whether the promoters are conscious of it or not) is this : The relative valuation of the present and future made by individuals is such as to lead to a rate of interest of 4 or 5 per cent., and this involves cutting down forests, and mining coal at a certain rate ; but the country as a whole should take longer views, give the future more weight than the individual cares to do, and so practically adopt an interest rate of, say, 1 or 2 per cent. ; the logical consequence being to spread the use of our natural resources far further into the future.

The true interest of the Government may be expressed as that of watching over the orderly development of the country. Rapid

ups and downs of an industry are both to be deprecated ; falling off means unemployment and distress, sudden expansion involves waste and speculation. The early history of Johannesburg affords good examples of the speculation brought by a rapid influx of capital and the undesirable consequences. It is not good even for a Government to be placed suddenly in possession of great new resources, for Governments have shown themselves—all over the world—unable to resist demands for extravagant spending. But if a large steady income from the mines can be put in the hands of the Government, there is at least a chance that it will be used to effect improvements in railways, roads, harbour, irrigation, and the like, to the permanent good of South Africa.

This argument does not show whether the production of the mines should be maintained at the present level, or slowly increased, or slowly decreased. The economic discussion already given is against an increase, and the legitimate vested interests of the community of the Rand are against a decrease ; the middle course is the more to be favoured if,

as suggested, a few years will be sufficient to cause the demand for gold to catch up with the supply.

The South African Government, in fact, possess the means of exercising an important influence on the monetary position of the world at large. It will be argued, no doubt, and quite rightly, that the Government's first duty is to its own citizens. Fortunately, there need be no serious conflict between that duty and any duty that South Africa may be considered as owing to the world. In the first place world prices react on South Africa, so that South Africa cannot afford to ignore the effect on them of its policy. And then the policy, if the preceding arguments are sound, which will best serve the needs of the country is not very different from that which is in the interests of the world.

The guide to policy should be maintenance of the level of prices. The present generation has only experienced depreciating money, and it has become familiar with the consequences —high interest, disappointing investments, and, especially, labour troubles. The generation before had a money that appreciated

steadily, and produced disturbances of other kinds. It will be conceded by most that the ideal is a money which shall maintain a level value ; if the South African Government can help to secure this, even at the cost of some immediate sacrifice, it would be rewarded by the avoidance of labour troubles due to increase in the cost of living.

Fortunately, the sacrifice need not be great, if the view is correct that the demand for gold is likely to overtake the supply before many years. By not pressing the output now, but reserving a large store of gold ore for development when prices show a tendency to fall, it will be possible to prevent great fluctuation in either sense for a generation or more. This would mean that the Witwatersrand's gold was being sold on a favourable market, and would perhaps allow time for commercial civilisation to advance far enough for a permanent settlement of the monetary question.

The world has of late become aware that there are fluctuations in its accepted standard of value, and that grave social inconveniences result ; knowledge of changes in value has

even led to discussion of remedies, first among economists, and now even amongst commercial and political people. The earliest suggestion was to adopt an index number as a standard, explicitly, for making important contracts, especially those involving long periods of time. Such a plan, however, would be too cumbrous for the commercial world, and would imply two different currencies, one for everyday use, the other for large transactions, involving the same kind of disadvantages as a country with a depreciated paper currency meets with. A much more ingenious plan has been devised by Prof. Irving Fisher, which would have the effect of making the coins and paper of any country adopting it, token money based on an international index number as standard. There is a great deal to be said in favour of this scheme ; still it may be doubted whether the world is not too conservative in its affection for the precious metals to take it up. Probably, it would be wiser at present to try, modestly, to render the value of gold more stable by the action of the law of supply and demand than to abandon gold as standard. This should not be too

difficult ; it is admitted that monopoly gives a means of controlling values to a certain extent ; also that even a private financial syndicate may succeed in partly monopolising the supply of a raw material. A private syndicate would, of course, be of no use in regard to the currency problem, since its interests would not coincide with those of the public ; but what could be done by a group of financiers could be done by the governments of the world, if they chose to unite.

There are, in fact, only four states within whose territories any noteworthy amount of gold is produced : the British Empire, the United States, Russia, and Mexico. An agreement between these four Powers would be enough to control the output of the world.

Control of output, however, implies purchase of or compensation to some of the mines, and as the benefits to be looked for are open to all nations it would be necessary to try and persuade them to join in the undertaking ; though the four states mentioned, or even Britain and America, might think it worth

while by themselves, and could do it if they chose.

It would be necessary first to appoint an International Commission of study to draw up a programme. The enterprise would be facilitated if the governments of the various countries were to acquire the mines in their own territories ; but this would not be indispensable. Eventually, an executive body would be instituted, and would be charged with the duty of guiding the constituent governments, which agreed to adhere to its policy.

At the present time the policy would be one of restriction, and the work of the executive would consist principally in deciding what annual output was desirable, and what mines should be worked in order to provide it ; in advising on this they would make also recommendations as to the compensation involved. This sounds perhaps a more formidable undertaking than it really is ; the mines to be closed down would naturally be the poorest, so that the compensation to shareholders would be small. Employees also must be considered (the Swedish Government has set

a good example in this matter in nationalising tobacco factories), but in their case compensation is only needed until they find other work, which should usually be but a short time.\*

\* The suggestion of controlling the gold output has been discussed more fully by the present writer in the *Journal des Économistes*, Paris, 1918.

# APPENDIX A

## TABLE I.

### OUTPUT OF GOLD IN THE TRANSVAAL AND ELSEWHERE.

(See p. 4.)

## TABLE II.

### WORLD OUTPUT OF GOLD.

[From *Soetbeer, Journ. Roy. Stat. Soc.*, vol. lvii., p. 370 (to 1889) and Reports of the Transvaal Chamber of Mines (1890 on).]

Year.	Metric tons.	£m.	Year.	Metric tons.	£m.
1841-50	548	74.8	1886	161	22.0
1851-55	988	134.9	1887	158	21.6
1856-60	1,030	140.7	1888	164	22.4
			1889	176	24.1
1861-65	926	126.4	1890	179	24.4
1866-70	960	131.0			
1871-75	853	116.5			
			1891	197	26.8
1876	166	22.7	1892	221	30.1
1877	179	24.5	1893	237	32.4
1878	186	25.4	1894	273	37.2
1879	167	23.8	1895	299	40.8
1880	163	22.4			
			1896	304	41.6
1881	161	22.0	1897	355	48.5
1882	154	21.0	1898	432	58.9
1883	149	20.3	1899	461	63.0
1884	156	21.3	1900	383	52.3
1885	156	21.3			

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TABLE II.—*continued.*

Year.	Metric tons.	£m.	Year.	Metric tons.	£m.
1901	393	53.6	1911	695	94.9
1902	446	61.0	1912	701	95.8
1903	493	67.3	1913	684	93.4
1904	523	71.4	1914	680	92.9
1905	572	78.1	1915	705	96.3
1906	606	82.7	1916	701	95.7
1907	621	84.9			
1908	666	91.0			
1909	683	93.3			
1910	685	93.5			

TABLE III.

## NET IMPORTS OF GOLD INTO INDIA.

[From various issues of the "Statesman's Year Book."]

(From 1800 to 1864 inclusive India absorbed £m256 of gold and silver.)

Year.	£m.	Year.	£m.
1866	—	1876	1.5
1867	+3.8	1877	0.2
1868	3.6	1878	0.5
1869	5.2	1879	-0.9
1870	5.6	1880	+1.7
1871	2.3	1881	3.7
1872	3.6	1882	4.8
1873	2.5	1883	4.9
1874	1.4	1884	5.5
1875	1.9	1885	4.7

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TABLE III.—*continued.*

Year.	Crores.	Year.	Crores.
1886	+2.76	1906	0.43
1887	2.18	1907	14.86
1888	2.99	1908	17.37
1889	2.81	1909	4.36
1890	19.4	1910	21.68
1891	5.64	1911	23.98
1892	2.41	1912	37.76
1893	-2.81	1913	34.01
1894	+0.64	1914	23.32
1895	-4.97	1915	7.65
1896	+2.53	1916	— 1.1
1897	2.29	1917	+13.24
1898	4.91		
1899	19.6		
1900	9.44		
1901	0.84		
1902	1.96		
1903	8.77		
1904	9.93		
1905	9.71		

TABLE IV.

INDUSTRIAL CONSUMPTION OF GOLD (NEW MATERIAL ONLY) IN U.S.A.

[From the U.S. Mint Reports.]

Years.	Metric tons.	£m.	Years.	Metric tons.	£m.
1881-85	84	11.5	1906-10	228	31.3
1886-90	99	13.5	1911-15	260	35.6
1891-95	89	12.1			
1896-00	92	12.5			
1901-05	171	23.5			

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TABLE V.

INDUSTRIAL CONSUMPTION OF GOLD IN THE WORLD  
(EXCLUDING THE ORIENT).

[From U.S. Mint Reports.]

Year.	Metric tons.	£m.	Year.	Metric tons.	£m.
1891	—	—	1906	183	25.0
1892	—	—	1907	149	20.4
1893	75	10.2	1908	117	16.0
1894	79	10.8	1909	—	—
1895	88	12.0	1910	168	23.0
1896	89	12.1	1911	172	23.5
1897	89	12.1	1912	187	25.6
1898	98	13.4	1913		
1899	109	14.9	1914		
1900	113	15.5	1915		
1901	—	—	1916		
1902	114	15.6			
1903	115	15.7			
1904	120	16.4			
1905	128	17.5			

[From *Soetbeer*, " Precious Metals " (Berlin, 1888).]

Year.	Metric tons.	£m.
1841-50	200	27
1851-60	280	38
1861-70	570	78
1871-80	840	115

NOTE.—The annual reports of the Director of the U.S. Mint are most valuable; indeed, the best source of information on the precious metals. But they are

unsystematically arranged; the grouping of the statistics is frequently changed without explanation; and sometimes a return is omitted altogether. There are also arithmetical mistakes. It is therefore quite possible that, in quoting statistics for these tables, the reports may have been misinterpreted in places.

TABLE VI.

ACTUAL AND REQUIRED STOCK OF GOLD (EXCLUDING THE ORIENT).

(In millions of pounds sterling.)

Date.	Gross output in periods of	Loss to India	Loss in industry five years.	Net in- creases	Stock.	Required stock.	Ratio per cent.
1841	25	0	10	15	95	227	44
1846	50	1	15	34	110	257	43
1851	135	2	15	118	144	291	50
1856	141	2	25	114	262	329	80
1861	126	7	30	89	376	372	101
1866	131	7	45	79	465	421	110
1871	116	11	55	50	544	477	114
1876	119	3	60	56	594	539	110
1881	106	23	61	22	650	610	109
1886	114	12	60	42	672	690	97
1891	167	0	60	107	714	781	91
1896	264	17	68	179	821	884	93
1901	331	20	80	231	1,000	1,000	100
1906	445	39	105	301	1,231	1,131	109
1911	473	84	120	269	1,532	1,280	120
1916	—	—	—	—	1,801	1,448	124
1921	—	—	—	—	—	1,639	—

Dates are January 1st of years given.

The stock on January 1st, 1901 is assumed to be £m1,000 (U.S. Mint gives for July 1st, 1900, 4,841

million dollars; for July 1st, 1901, 4,907; mean, 4,874, equal to £m1,001).

The seventh column gives the stock calculated to increase uniformly at  $2\frac{1}{2}$  per cent. per annum, that for 1901 being taken as basis.

TABLE VII.

## STATISTICS OF PRODUCTION.

[From Mulhall's & Webb's Dictionaries, "Statesman's Year Book," and "Whitaker's Almanack."]

COTTON (millions of pounds).		WOOL (millions of pounds).		PIG IRON (thousands of English tons).	
1831	820	1820	560	1830	1,585
1840	1,310	1840	786	1840	2,680
1850	1,435	1860	1,108	1850	4,422
1860	2,551	1880	1,988	1860	7,180
1870	2,775	1887	2,218	1870	11,910
1880	3,601	1894	2,390	1880	18,140
1891	5,600	1902	2,651	1889	25,160
1897	5,900	1906	2,605	1895	29,300
1902	8,660			1905	52,200
1906	10,490				

COAL (millions of English tons).		GRAIN (for men and beasts, millions of tons).		MEAT (millions of tons).	
1820	17.2	1831-40	101	1831-40	8.7
1840	44.8	1851-60	139	1851-60	10.5
1850	81	1875-84	204	1875-84	13.3
1860	142	1888	241	1888	14.4
1870	213	1895	232	1895	15.2

TABLE VII.—*continued.*

COAL (millions of English tons).		GRAIN (for men and beasts, millions of tons).		MEAT (millions of tons).	
1880	340	1915	376		
1889	485				
1897	610				
1907	1,080				

(Grain and meat are for Europe, Colonies, and U.S.A. only).

SUGAR (thousands of English tons).		TEA AND COFFEE (thousands of English tons).	
1831-40	530	1831-40	210
1851-60	1,100	1851-60	390
1875-84	3,670	1875-84	745
1888	5,260	1888	920
1907	14,100	1905	1,300
1913-14	16,080		

TABLE VIII.

RATE OF INCREASE IN PRODUCTION OF COMMODITIES.

(See p. 30.)

## APPENDIX A

TABLE IX.

## GOLD, AND INDIVIDUAL DEPOSITS SUBJECT TO CHEQUE, IN U.S.A.

[U.S. Mint Reports: and *Fisher, Amer. Econ. Rev.*,  
vol. v.]

In millions of dollars on June 30th.

Year.	Gold.	Deposits.	Ratio.
1896	600	2,710	4.5
1897	696	2,660	3.8
1898	861	3,220	3.7
1899	962	3,880	4.0
1900	1,034	4,440	4.3
1901	1,125	5,130	4.6
1902	1,192	5,400	4.5
1903	1,249	5,730	4.5
1904	1,328	5,770	4.4
1905	1,358	6,540	4.7
1906	1,473	6,810	4.6
1907	1,466	7,130	4.9
1908	1,615	6,570	4.1
1909	1,641	6,680	4.1
1910	1,635	7,230	4.3
1911	1,753	7,780	4.3
1912	1,813	8,170	4.5
1913	1,867	8,150	4.4
1914	1,872	8,890	4.7
1915	1,973	—	—

TABLE X.

## DEPOSITS IN BANKS OF UNITED KINGDOM (INCLUDING THE BANK OF ENGLAND).

(Current and time deposits are not distinguished.)

[*Economist*, Banking Number, 1916.]

Year.	£m.	Year.	£m.
1896	731	1911	973
1897		1912	1,015
1898		1913	1,054
1899		1914	1,104
1900		1915	1,290
1901	827	1916	1,405
1902		1917	
1903			
1904			
1905			
1906	861		
1907	885		
1908	891		
1909	925		
1910	939		

The figures are for January 1st in each year.

NOTE.—Statistics of bank deposits are given in the *Economist*, *Bankers' Magazine*, "Statesman's Year Book," and elsewhere. All the different authorities give different figures.

## APPENDIX A

TABLE XI.

## RESOURCES OF FRENCH BANKS.

[Aldrich Currency Report, Statistics, vol. ii., p. 345.]  
In millions of francs.

Year.	GOLD.		SILVER.		Notes in circulation.	Deposit and current account.	
	B. of Fr.	Total.	B. of Fr.	Total.		B. of Fr.	Four other chief banks.
1878	1,114	5,000	960	3,000	2,339	(1,390)	
1885	1,103	5,000	1,073	3,000	2,846	(1,469)	
1891	1,279	4,000	1,255	2,500	3,085	740	1,409
1897	1,963	4,200	1,222	2,175	3,687	833	1,993
1903	2,493	4,800	1,110	2,130	4,310	615	2,923

The deposits include some time deposits.

Silver is taken at its nominal value.

TABLE XII.

## RESOURCES OF GERMAN BANKS.

[Aldrich Currency Report, Statistics, vol. ii.]  
In millions of marks.

Year.	Gold and silver in Reichsbank.	Notes in circulation.	Deposit and current account, all joint stock banks.
1880	562	735	529
1885	586	727	1,034
1890	801	984	1,509
1895	1,012	1,096	2,243
1900	817	1,139	3,502
1905	973	1,336	5,745

TABLE XIII.

ESTIMATED CURRENCY FACTORS (*see* definition,  
p. 47.)*United States.*

Period.	Average.		
	Money and deposits in circulation.	Gold.	Factor.
1896-1900	4,374	831	5.3
1901-1905	7,054	1,250	5.2
1906-1910	8,526	1,606	5.3
1911-1914	10,015	1,826	5.5

[*Fisher*, "Purchasing Power of Money" and U.S. Mint reports.]

Quantities in millions of dollars.

*United Kingdom.*

	In millions sterling.		
	1895.	1903.	1910.
Gold in circulation outside banks	72	75	84
Silver	24	24	24
Notes	40	44	45
Sixty per cent. of deposits..	415	505	585
Total currency ..	551	648	738
Gold coin (Mint estimate) ..	92	100	113
Bullion in B. of E., say ..	13	17	19
Total gold .. ..	105	117	132
Factor .. ..	5.2	5.5	5.6

The British gold coin in the country has been estimated from time to time by the Mint. We have assumed that half the gold in the Bank of England is foreign coin and bullion ; also that the other banks hold gold equal to 1 per cent. of their deposits. These assumptions may be far from the truth ; English banking statistics are in a most unsatisfactory state.

*France.*

(In millions of francs.)

(See Table XI.)

	1878.	1885.	1891.	1897.	1903.
Gold outside Bank of France ..	3,886	3,897	2,721	2,237	2,307
Silver ditto ..	2,040	1,927	1,245	953	1,020
Notes .. ..	2,339	2,846	3,085	3,687	4,310
Deposits .. ..	1,390	1,469	2,149	2,826,	3,538
Total currency	9,655	10,139	9,200	9,703	11,175
Total gold ..	5,000	5,000	4,000	4,200	4,800
Factor.. ..	1.9	2.0	2.3	2.3	2.3

The amount of gold in circulation at the earlier dates is probably exaggerated.

TABLE XIV.

YIELD AND WORKING COSTS OF THE WITWATERSRAND  
MINES.

(See p. 90.)

TABLE XV.

 PRICE OF STORES PURCHASED BY THE TRANSVAAL GOLD MINES.  
 [Transvaal Chamber of Mines Reports, 1908 to 1915.]

	£ per	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.
Coal (steam) ..	ton	0·604	·608	·610	·605	·565*	·510	·513	·520
Blasting gelatine ..	case	2·60	2·33	2·27	2·28	2·28	2·27	2·30	2·30
Gelignites ..	case	2·00	1·87	1·80	1·71	1·79	1·76	1·86	1·80
Cyanide ..	lb.	0·0412	·417	·413	·415	·416	·418	·431	·522
Candles ..	lb.	0·0211	·186	·189	·180	·174	·179	·187	·204
Meal ..	bag	0·522	·670	·561	·582	·575	·660	·607	·530
Meat ..	lb.	0·0139	·129	·116	·151	·156	·149	·136	·130
Oregon and pitch pine ..	cu. ft.	0·184	·186	·184	·190	·196	·210	·209	·202
Zinc ..	lb.	0·0155	·151	·155	·165	·221	·167	·169	·270
Steel sheet ..	lb.	0·0074	·69	·72	·70	·73	·73	·80	·91
Shoes and dies ..	lb.	0·0092	·92	·90	·90	·90	·91	·91	·104
Safety fuse ..	coil	0·0177	·178	·178	·183	·180	·172	·171	—
Lime (white) ..	bag	0·300	·296	·276	·253	·246	·248	·235	·230
Rock drill steel ..	lb.	0·0151	·149	·152	·150	·149	·150	·166	·168

\* Railway rates reduced.

The articles are placed in approximate order of importance.

## APPENDIX B

### THE VALUATION OF MINES.

(From the *Journal of the Chemical, Metallurgical and Mining Society of South Africa*, for July, 1916.)

By PROF. R. A. LEHFELDT, D.Sc.

THE problem of estimating the present worth of a mine has usually been dealt with mathematically only to the extent of capitalising dividends at various assumed rates of interest.\* Arithmetical examples dealing more fully with capitalisation and working costs are given by some writers,† but without an algebraic basis. It is sometimes thought that the data of mining are too uncertain to make it worth while to apply mathematical methods to them ; but arithmetical treatment suffers from the disadvantage that it does not show what is the effect of varying the factors involved, so that misleading conclusions may easily be drawn from the more or less accidental cases which are chosen for working out.

In the present paper an attempt is made to deal with the question mathematically, with the aid of

\* Hoover, H. C., "Principles of Mining." Lawn, J. G., "Mine Accounts and Mining Book-keeping."

† Ross Browne, "Working Costs of the Mines of the Witwatersrand" (Appendix 3) (Johannesburg, 1907). Memo. on Far East Rand, by the Government Mining Engineer (R. N. Kotze), pp. 8, 14, 15 (Cape Town, 1916).

assumptions that are not too far from the facts to be of practical service.

Let there be a mine containing  $X$  tons of ore whose average value is  $p$  pounds per ton. The mine is worked on the scale of  $x$  tons per year : the working costs on this scale are  $q$  pounds per ton, and the capital required  $C$  pounds. Let  $i$  be the rate of interest.

The life of the mine is  $X/x = T$ .

In any short time  $dt$  the ore milled is  $xdt$ , and the working profit made is  $(p-q)xdt$ .

If the time  $t$  be counted from the time of starting the mill, and the value of the mine at that moment is required, each element of profit must be discounted at the rate of  $e^{-it}$ , so that the whole present worth of the working profit is

$$= \int_0^T e^{-it} (p-q) xdt = (p-q) x \left\{ \frac{1-e^{-iT}}{i} \right\}$$

but as this can only be obtained by means of the capital outlay  $C$  the net value of the mine at the time of starting the mill is

$$V = (p-q) x \left\{ \frac{1-e^{-iT}}{i} \right\} - C \dots \dots \dots \quad (1)$$

Here the capital that has been spent earlier must be accumulated at compound interest  $i$  up to the given moment ; in other words,  $C$  is the " accrued capital," in Mr. Kotze's sense of the term.

It will be noticed that this formula is not, like those in the books quoted, based on two rates of interest. That is an inadvisable way of expressing the facts. There is only one rate of interest ; the compensation that a capitalist requires on account

of the risk of mining is another matter. It is hardly necessary to remark that the rate of interest has long ceased to be anywhere near 3 per cent. At present it is about 5 per cent.—the yield on good Government stocks, and some such rate should be taken in dealing with amortisation, and with accumulation of capital expenses.

To make use of the formula for  $V$  it is necessary to assume forms for the quantities  $q$  and  $C$ , which are functions of  $x$ . The simplest form that is reasonably near the fact is the linear form. Accordingly, I shall put

$$C = C_0 + cx$$

where  $C_0$  and  $c$  are constants. This is equivalent to dividing the capital expenditure into two parts, one fixed in amount (for the given mine), the other proportional to the scale of working. The former part may, it is true, be a function of  $X$ , the size of the mine, but that point need not be considered for the moment.

Similarly the working costs may be divided into fixed annual charges and a part proportional to the tonnage milled, giving

$$q = \frac{Q}{x} + r$$

where  $Q$  and  $r$  are constants.

Substituting, and remembering that  $x = X/T$ , we have

$$V = \left\{ (p-r) \frac{X}{T} - Q \right\} \left( \frac{1 - e^{-rT}}{i} \right) - C_0 - \frac{cX}{T}. \quad (2)$$

Hence, for a given mine, in order that the present worth should be a maximum the scale of working

must be such as to make the life  $T$  satisfy the equation

$$\frac{dV}{dT} = 0$$

$$\text{or } \left\{ \frac{(p-r)X}{T^2} \right\} \left( \frac{1-e^{-iT}}{i} \right) - \left\{ \frac{(p-r)X}{T} - Q \right\} e^{-iT} + \frac{cX}{T^2} = 0$$

$$\text{or } e^{-iT} = \frac{\frac{1}{i} - \frac{c}{p-r}}{\frac{1}{i} + T - \frac{QT^2}{X(p-r)}} \quad \dots \quad (3)$$

This equation cannot be solved directly, but it is easily evaluated with the aid of a table of exponentials.

Through the courtesy of the officials of the Department of Mines, I have obtained some figures representing approximately the constants in the above equations as applied to gold mining in the East Rand area. The figures should not be applied to different conditions without separate consideration ; and, in particular, the linear form of the expressions for  $C$  and  $q$  is only applicable within moderate limits of scale. The numbers given below may be regarded as applicable to mines of about 1,000 to 3,000 claims, equipped according to the present standard of mining engineering.

The capital expenditure necessary depends on (i.) the depth, (ii.) extent of the mine, (iii.) scale of working. Accordingly, in comparing one mine with another, the value of  $C_0$  may vary on account of difference in depth ; and  $c$ , so far as it depends on shaft sinking, will vary too. Further, it is difficult to bring the number of shafts into relation with the extent of the mine, and only through that connec-

tion can it be related to the scale of working ; moreover, technical practice seems to vary much on this point. On the other hand, the outlay on advance development is approximately proportional to the scale of working, and the cost of equipment depends almost exclusively on the scale of working, but is not proportional to it.

Experience for mines of average depth may be summed up in the values

$$C = £500,000$$

$$c = £1.5 \text{ per ton milled per year.}$$

To check the accuracy of these values I give the comparison between calculation and experience in a few instances.

#### *Capital Expenditure.*

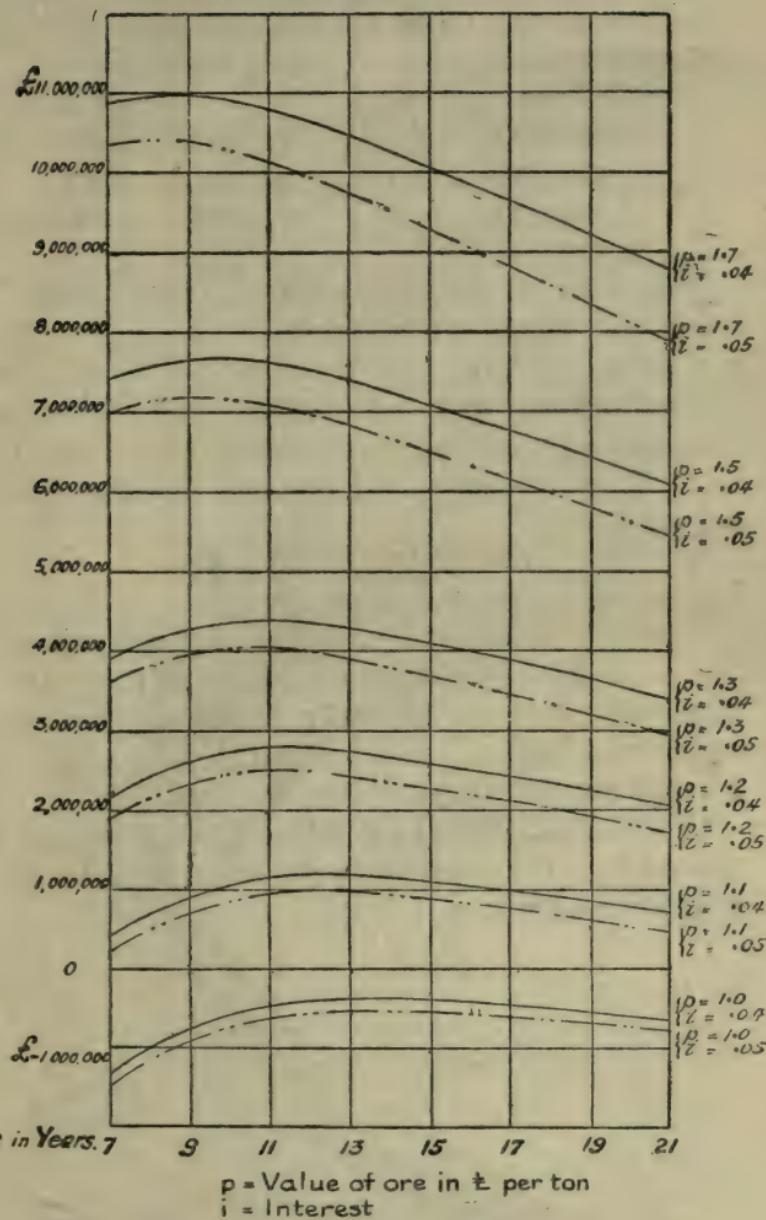
		By formula.	Actual.	Years before starting mill.
Brakpan	..	£1,580,000	£1,185,000	7
Geduld	..	950,000	1,100,000	12
Govt. Areas	..	1,400,000	1,570,000	6
Modder Deep	..	1,000,000	672,000	5
Van Ryn Deep	..	1,250,000	1,155,000	8

Working costs vary considerably with depth, but have no direct relation to the extent of the mine. Assuming an average depth of 3,500 ft., they may be represented with sufficient approximation by the formula given above, with

$$Q = £150,000 \text{ per year.}$$

$$r = £0.68 \text{ per ton milled.}$$

Fig 9



The results of the formula  $q = Q/x + r$  agree closely with an empirical curve, supplied by the Department of Mines. It yields these results.

$x$ Tons.	$q$
600,000	£0.930 or 18/7
900,000	0.847 16/11
1,200,000	0.805 16/1
1,500,000	0.780 15/7

But what is called "working costs" does not cover the whole expenditure of the mines. There are other expenses that it is customary to charge against net revenue, on one pretence or another, thus making the mines seem cheaper to run than they are. These expenses add quite a shilling a ton, so we will take

$$r = £0.75 \text{ per ton milled}$$

instead of the figures given above.

Further, in working out the most advantageous life of a mine by equation (3) it is necessary to know  $X$ . But as this only comes in in a small correction term it will be sufficient to take an average amount, say, 20,000,000 tons.

The results for ore of different grades, taking the rate of interest at either 4 per cent. or 5 per cent., are shown on Fig. 9.

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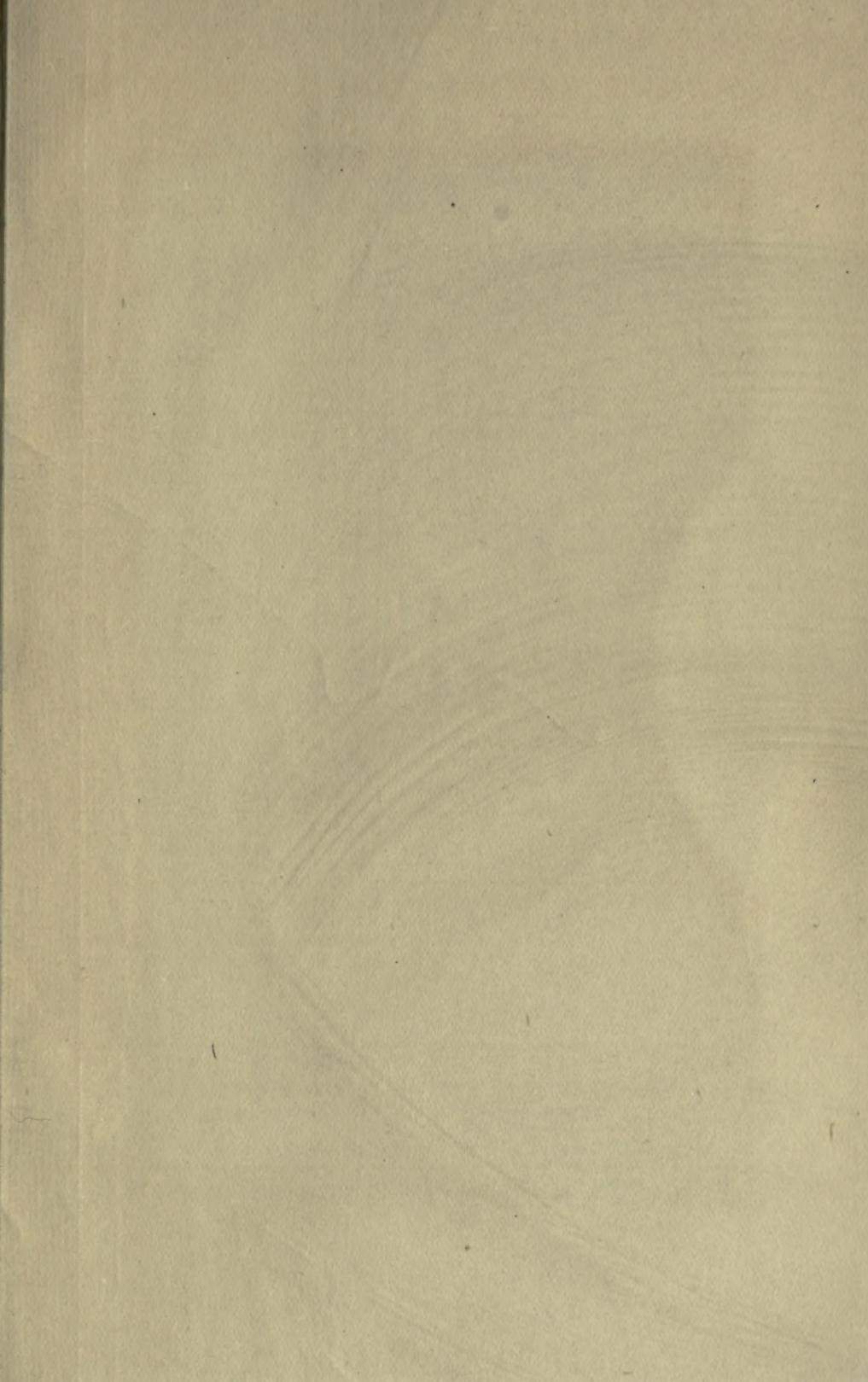
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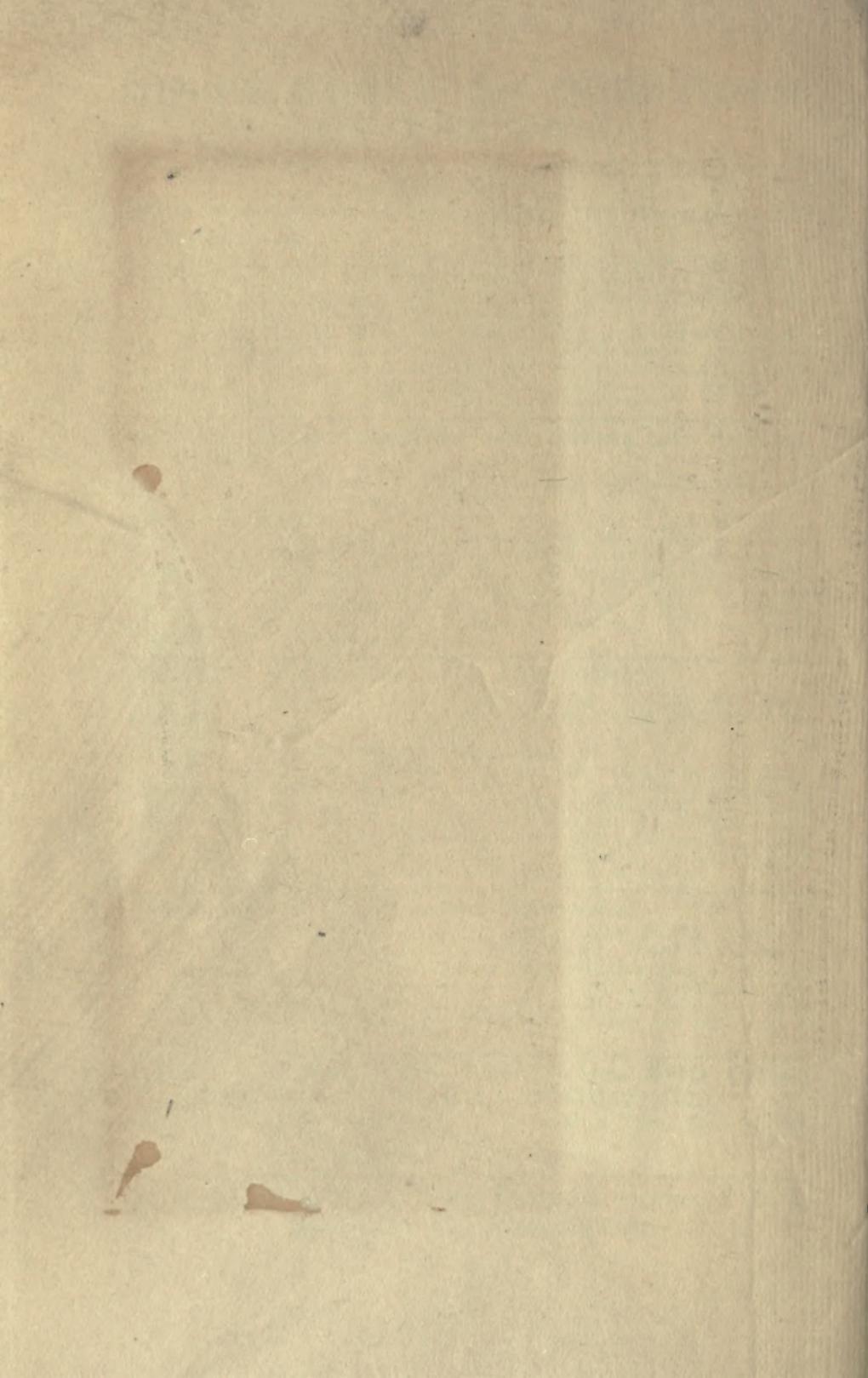
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